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A Comprehensive Feasibility Study for a Wooden Plastic Composite Project

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RIT

A Comprehensive Feasibility Study for a Wooden Plastic Composite Project

By

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Abstract

Millions of tons of wastage are produced every year ending up in landfills or burn and causing an environmental problem as they threaten the health of creatures and cause resources depletion. 44% of wastage is organic waste, which is biodegradable. However, 17% and 12% of wastage are paper and plastic respectively, and both are non-degradable. Thus, the comprehensive solution is to recycle them.

A suggested solution is to recycle them into wood plastic composite. Up to 90% of WPC raw material is a recycled material, and the final product is 100% recyclable. WPC is comparatively less energy-consuming than other substitute materials as WPC is formed at 180°C, while others need up to 1200°C. In 1990, WPC has emerged in Italy, and it gained its quadruple growth in 2000. By 2024, WPC is expected to reach sales of 8.2 billion $ in market with an annual growth rate of 9.3%. WPC is a thermoplastic reinforced with wood flour. Wood flour has the lowest gravity weight compared to other reinforcing materials, and it enhances modulus of elasticity of the final product. WPC contains 50% recycled wood flour, 40% recycled thermoplastic, and 10% additives. Its formula percentage depends on its intended application. WPC components may receive several types of treatments; chemical treatments to facilitate the production process and improve the final product characteristics; thermal, energetic, and Corona treatments to enhance bonding between plastic and wood particles.

Market analysis shows WPC is a prospective product with multiple applications, as it overcomes substitute materials in many points such as being splinter free, easy to install, lightweight, natural-looking, cost efficient, timeless guaranteed, environmentally friendly, recyclable, fire retardant, weather-resistant, anti-fungus, and nontoxic. Egypt consumes 38% of the softwood market in the Middle East, and this study shows that manufacturing WPC in Egypt is a profitable project.

Keywords: WPC Feasibility Study; Wood Plastic Composite; Reinforced Material; WPC Market Study; WPC Financial Study; WPC Technical Study.

Table of Contents

1 Appendix-1- Proposal

1.1 Overview

Due to population growth and economic activities, the quantities of wastes in the World have increased in the last decade. Most of the waste ends up in municipal landfills or dumpsites. Waste management in the country is coordinated through local authorities. Waste issues are handled through recycling and converting waste to energy and resources. By implementing new technologies, the process of waste management can be improved as it allows for more efficient waste separation and collection systems. Through efficient waste management, the world aims to reduce the adverse per capita environmental impact of cities.

In the UAE, local environmental challenges [1] include invasive species, carbon footprints, limited water resources, overfishing, waste generation, air pollution, and land degradation, and desertification. These challenges are the result of rapid development and the effects of climate change and global warming. Protection of the environment and sustainable development are key topics that receive great attention from the UAE Government. Furthermore, studies have shown that hundreds of camels across the UAE have died due to the ingestion of plastic waste over the past decade [2]. Of 30,000 camels' analyses since 2008, in the field or in a laboratory by staff from Dubai's Central Veterinary Research Laboratory, about 300 died because of poly-bezoars – lumps of indigestible material made of plastic. That translates to about one in 100 camel deaths in the UAE due to the consumption of plastic waste left behind by humans either camping or generally littering.

1.2 Background

The Ministry of Economy [3] started recording recycling as an independent sector since 2015 in its annual statistical report. The number of jobs in the recycling industry was recorded 400 in 2016. Generally, recycling generates more jobs per unit of waste than incineration and landfill. The employment factor for recycling is usually defined in terms of jobs per ton of recycled material. The factor is wide-ranging as it is partly dependent on the composition of materials. According to studies in parts of Australia and the US, 1-2 jobs are generated per 1,000 tons of recycled material. Of the 6.3 million tons of municipal solid waste generated in 2016, around 957,433 tons (15.1%) were recycled and 24.2% were recovered from landfills (including composting and other methods). This can be translated into 1,436 recycling jobs, taking the average of the factors above. If the national goal of 75% recovery is achieved by 2021 (50% recycling), without increasing the total amount of municipal waste, around 4,725 recycling jobs would be generated. If 100% recycling is realized by 2030, this could lead to up to 9,450 jobs. There would be additional employment from recovering non-municipal waste.

1.3 The Objectives

This project attempts to present the best solution for the aforementioned environmental problem. The solution promotes maximum utilization of world waste while also providing an economic incentive to encourage its implementation; thus, reducing the amount of dumped waste and ensuring the sustainability of natural resources such as plastic and wood while simultaneously providing suitable job opportunities. The result is the transformation of unsightly landfills into an aesthetically appealing product.

1.4 The Proposed Solution

Figure-1 shows that aside from Organic Waste, which is mostly biodegradable, the majority of waste produced in the UAE is paper and plastic.

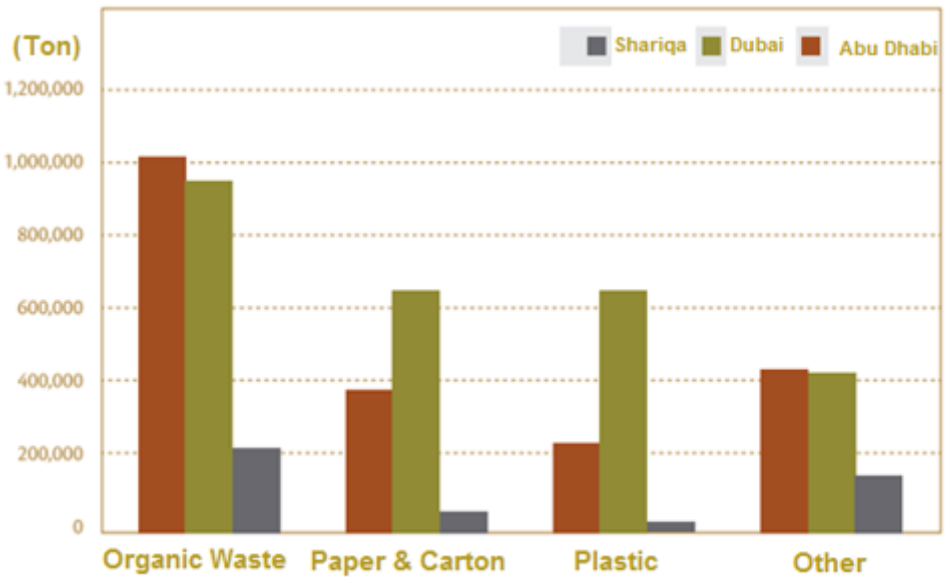


Figure-1: The value of wastage in tons in three emirates (Dubai, Sharjah, and Abu Dhabi)

The proposed solution combines both types of waste in addition to some additives that improve composite properties. The result will be a plastic wood composite that combines the characteristics of its main component. Wood-Plastic Composites are fire-resistant, insect-proof, dimensionally stable, does not require periodic maintenance, and is moisture resistant. They have multiple applications such as in the manufacture of furniture, doors, windows, pergola, façades, deck floors, railings, landscaping timbers, cladding and siding, park benches, molding, and window frames and doors, pallet, indoor-outdoor applications, garden furniture, marine walls, and piling. 90% of the raw materials that go into Wood-Plastic Composites production are recycled material. **Figure-2** highlights the product advantages.

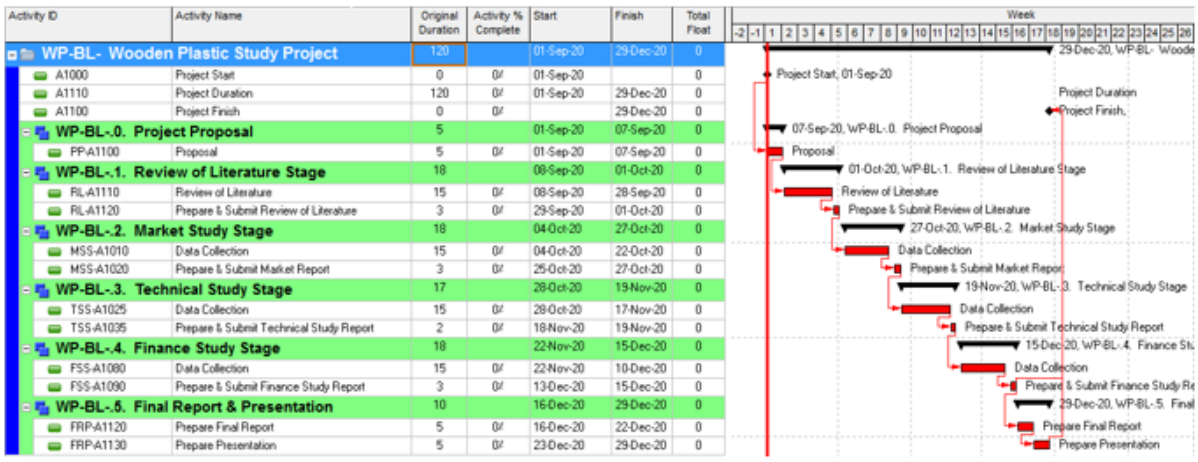
Figure-2: WPC advantages.

1.5 Methodology

This report aims at providing a detailed analysis of WPC products. Initially, technical information about the product is presented after reviewing literature issued during the last six years. Afterwards, a complete marketing study is conducted that includes the market needs, global trends, market competitors and developing an integrated marketing plan. Based on the marketing study, technical studies will determine the required machines and their capacity, the required additives and their percentages, and the production process to determine the appropriate tools and machine distribution. Finally, the study will include a financial analysis to determine the required funding, profitability, and cash flow.

1.6 Measurement and Reporting

The project will have an estimated duration of 120 Days. Project is composed of four stages, and each stage is concluded by a report submission highlighting the findings of the stage. The first stage will be review of literature, the second stage will be market study, the third stage will be technical study, and the final stage will be financial study. At the end, a final report is compiled from the reports of each stage, and a presentation will be prepared summarizing the project deliverables. **Figure-3** shows the project time schedule.



Activity ID	Activity Name	Original Duration	Activity % Complete	Start	Finish	Total Float
WP-BL- Wooden Plastic Study Project		120		01-Sep-20	29-Dec-20	0
A1000	Project Start	0	0%	01-Sep-20		0
A1110	Project Duration	120	0%	01-Sep-20	29-Dec-20	0
A1100	Project Finish	0	0%		29-Dec-20	0
WP-BL-.0. Project Proposal		5		01-Sep-20	07-Sep-20	0
PP-A1100	Proposal	5	0%	01-Sep-20	07-Sep-20	0
WP-BL-.1. Review of Literature Stage		18		08-Sep-20	01-Oct-20	0
RL-A1110	Review of Literature	15	0%	08-Sep-20	28-Sep-20	0
RL-A1120	Prepare & Submit Review of Literature	3	0%	29-Sep-20	01-Oct-20	0
WP-BL-.2. Market Study Stage		18		04-Oct-20	27-Oct-20	0
MSS-A1010	Data Collection	15	0%	04-Oct-20	22-Oct-20	0
MSS-A1020	Prepare & Submit Market Report	3	0%	25-Oct-20	27-Oct-20	0
WP-BL-.3. Technical Study Stage		17		28-Oct-20	19-Nov-20	0
TSS-A1025	Data Collection	15	0%	28-Oct-20	17-Nov-20	0
TSS-A1035	Prepare & Submit Technical Study Report	2	0%	18-Nov-20	19-Nov-20	0
WP-BL-.4. Finance Study Stage		18		22-Nov-20	15-Dec-20	0
FSS-A1080	Data Collection	15	0%	22-Nov-20	10-Dec-20	0
FSS-A1090	Prepare & Submit Finance Study Report	3	0%	13-Dec-20	15-Dec-20	0
WP-BL-.5. Final Report & Presentation		10		16-Dec-20	29-Dec-20	0
FRP-A1120	Prepare Final Report	5	0%	16-Dec-20	22-Dec-20	0
FRP-A1130	Prepare Presentation	5	0%	23-Dec-20	29-Dec-20	0

Figure-3: Capstone Project Schedule Base Line.

1.7 Risks

The risks of the project will lie in the availability of the information on time, which may affect the project duration.

1.8 Executive Summary

There are problems related to the steady increasing of waste, which in results in the depletion of natural resources and poses a threat to the health of creatures and the environment around us. Therefore, we have to find an innovative solution that contributes to preserving the environment and natural resources and ensures sustainability. That solution should be economically attractive to ensure its continuity. The plastic wood industry is a comprehensive solution to those problems and adds an aesthetic and civilized appearance. It also contributes to solving the unemployment problem.

Appendix-2- Review of Literature

2.1. Market Study and Plan Introduction

Due to recent innovations, new composites have emerged that have unique physical and chemical properties capable of meeting the current industry requirements. The production of Wood Plastic Composites (WPC) has developed rapidly in recent years and is expected to change the future of industries for years to come. This is because WPC can be created entirely from recycled materials and has multiple functional capabilities, such as: moisture resistance, rot resistance, weather resilient, fire retardant, environmentally friendly, natural wood look and feel, termite and fungus resistant. For these reasons, the market for WPC has seen an immense growth.

The objective of this report is to demonstrate the importance of the usage of WPC products, particularly in developing countries, as they are characterized by their higher amount of material wastage. To demonstrate this, a market analysis will be performed to highlight the economic value of WPC implementation. Secondly, the production process will be analyzed and explained to determine which production methods are the most efficient for implementation.

2.2. Market Analysis

2.2.1. Market Share and Expected Growth

As discussed previously, the first step in determining the need for WPC products is to analyze the economic value of its implementation. The sector first began gaining momentum in the 1990s, and the period between 1997 and 2000 saw the market of WPCs quadruple in growth [4]. By 2024, the global market of bio-composites is estimated to reach 8.2 billion by 2024 [5] with an estimated global compound annual growth rate of 9.3% during that period [6]. In Europe, market growth is expected to be even higher, with an estimated annual growth rate of 10.2% [6]. The expected annual growth of the WPC revenue in Germany is demonstrated in **Figure-4.**

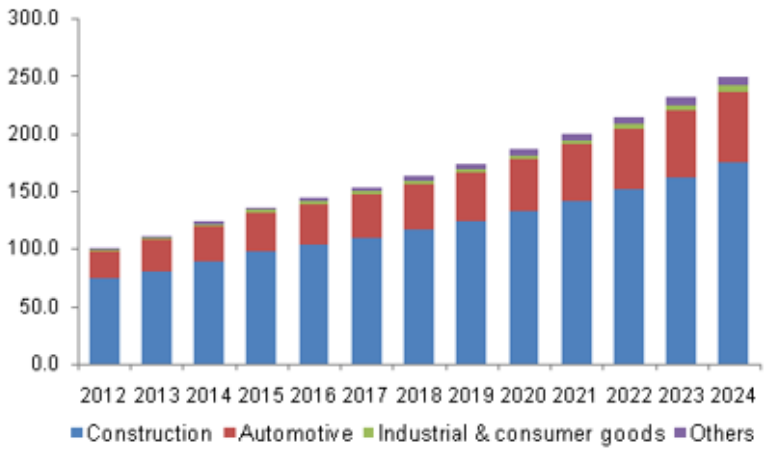


Figure-4: German Wood Plastic Composite market revenue, by Application (USD Million) [7]

2.2.2. Market Uses

One reason for the large expected market growth can be attributed to the versatility of the product. As it can be seen in **Figure-5**, WPC can have various applications in the automobile industry, the construction field, industrial and consumer goods, the medical field, and in 3D printing. The characteristics of WPC brings multiple functional advantages that promotes its use in the aforementioned industries.

In the construction industry, which accounts for the highest market share, Wood-Plastic Composites mainly have outdoor applications, such as in furniture, internal decoration, decking, siding, fencing, and cladding [6]. This is because of the material's aesthetic appeal, durability, light-weight nature, and ability to resist moisture. However, cladding [27] has to match materials which by experience performs satisfyingly over 5 decades. This lifetime is determined by norms, such as EN 1990 and EN 199, which provide 50-year wind loads as the basis for the proof of the cladding's structural fitness. While to date, WPC cladding could not yet demonstrate if it indeed lasts 50 years in a façade application. It is undoubtedly that each material will suffer from strength decreases provoked by aging effects. The key is to find out about the expected strength loss of a WPC cladding even before it is installed at a building. Based on the literature reviewed, there is not yet any national or European approval for WPC cladding. manufacturers have faced a lack of information about how to assess this long-term material degradation for their product. By today there is no applicable concept according to which biobased plastics can be developed for high durability in façade applications as demanded by building codes. Relevant norms and guidelines in the field of WPC compound and façade application were reviewed to find out about the applicable durability-related tests for WPCs. It was found that three basic standard methods are mainly used in type tests which are (1) accelerated weathering by UV-radiation to degrade the plastics matrix, (2) fungal decay tests to impair the biological components in WPC, and (3) thermohygric weather cycles to reduce bonding between fiber and matrix by swelled and frozen fibers. Currently, in the market suppliers provide outdoor cladding with WPC composite include PVC material as a thermoplastic, and hardwood fibers and dark color additives have a favorable effect on the WPC's durability.

In the automobile industry, the use of WPC in exterior and interior components has seen an increase in recent years [6]. This is attributed to the durability, cost-efficiency, and lightweight nature of the material and research has shown that the use of WPC in cars can contribute to a weight reduction of 30.0 % and a cost reduction of 20.0 % [5].

Originally, the composites were used as deck boards, picnic tables, and industrial flooring. This has led the decking market to become the largest WPC application, and that

market is continuing to grow [21]. Moreover, composites have a common application in windows and door components, making it the second-largest market for WPC applications [21].

In addition to the markets where WPCs have an existing strong presence, there are other emerging markets which have studied the utilization of WPCs in their products. An example of such an application is thermal insulation in lightweight buildings. This is due to the high latent heat of fusion of WPCs as well as other thermal properties that allow them to control and release energy efficiently [22]. This is further enhanced with the addition of microencapsulated phase change materials (MEPCM) which further enhances the thermal properties of composites, reducing temperature fluctuations inside the building [22]. This implementation is long term economic and environmental benefits as it reduces the amount of energy required for heating and air-conditioning.

Another market where WPC products are starting to establish their presence is in pallet manufacture. In the United States, 500 million pallets are manufactured every year, in addition to 2 billion pallets that are already in circulation [23]. This market is also predicted to grow at a compound annual growth rate of 5.24% [23]. Pallets are significant in many industrial processes are they improve handling, reduce storage costs, and provide a strong advantage in the transportation of materials in the supply chain. The majority of pallets (86%) are made from wood. This however comes with its disadvantages, as wooden pallets are prone to degradation due to fungi, moisture, and heat [23]. These disadvantages can be mitigated if Wood-Plastic-Composites are used instead, and the treatment that goes in their production can prevent this environmental degradation from occurring. **Figure-5** shows the current market share of pallets by size. The objective of this is to demonstrate the potential market for WPC pallets, which can be a substitute for the currently used wooden or plastic pallets.

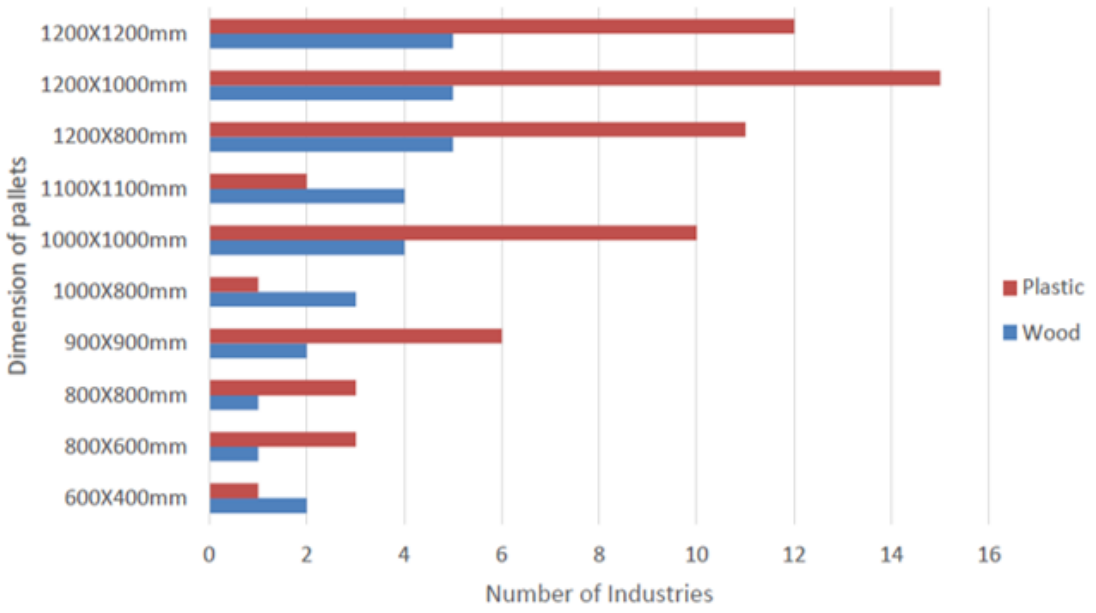


Figure-5: Market Share of Pallets by size [20]

2.3. Environmental Value

Another reason for the expected market growth of WPC can be attributed to the environmental value it can provide. Due to the current global emphasis on sustainability and environmental awareness, there is a growing need for more sustainable industrial products. WPC, as a product, is ideal for this sustainable approach and allows for a more economical use of natural resources. This is mainly because WPC utilizes agricultural residues, plastic and wood wastes and combines them with agents and additives to generate the composite [8]. This is ideal for countries that want to implement more strict waste management procedures. In the EU for example, it is estimated that 6 tons of waste per person are generated annually [16]. 34.7% of this waste is as a result of the construction sector, 28.2% is generated in the mining sector, while 10% of the waste is attributed to manufacturing [16]. WPCs provides an extension to the useful life of materials, a reduction of waste, and diminishes natural resource depletion. In Nigeria, it is estimated that millions of tons of plastic wastes are generated annually [8]. If this waste is utilized and processed to create Wood-Plastic Composites, the amount of plastic waste would decrease while simultaneously creating a product that has various market uses, leading to sustainable profit. Moreover, this would reduce the amount of landfill waste, thus reducing its adverse environmental impacts. Besides, the production of WPC is comparatively less energy-consuming [27] compared to conventional building materials such as metal or cementitious products. WPC is compounded by 180 C whereas cement is sintered by 1200 C its positive point toward WPC.

To further emphasize on the positive environmental influence of WPC, it is worth noting that the raw materials required to create the product may be generated from one organization [9]. In a study conducted by Lappeenranta University in 2012, they discovered that their organization generate over 105 tons of the fiber material required for WPC annually as waste [9]. Their study concludes that this waste presents a huge potential for profit and environmental sustainability if it was better utilized in Wood-Plastic Composites. This study is highlighted in **Figure-6.**

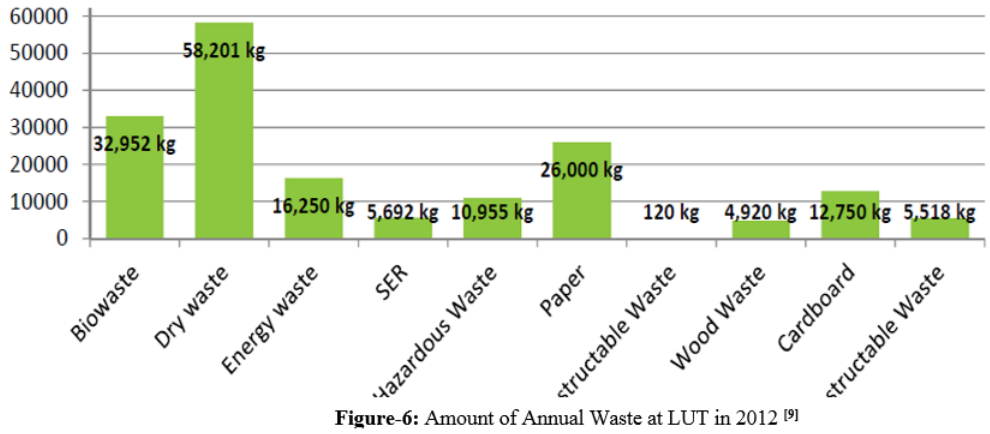


Figure-6: Amount of Annual Waste at LUT in 2012 [9]

2.4. Technical Analysis

The use of WPC began in the 1970s in Italy was the actual start in real application, however, the researches had existed since 1950 in USA. By the start of the 21st century, the composite saw a much wider implementation in North America, while also making its way to India, Singapore, Malaysia, Japan, and China [18]. To demonstrate the value of widespread WPC implementation, it is vital to understand the technical aspects of the product. The objective of these sections is to analyze the industrial processes used to create WPC products, highlighting the advantages of the product and potential areas of improvement.

2.4.1. WPC Production Process

There are four primary types of extrusion systems used to process WPC profiles [24]. These are the (1) single screw, (2) co-rotating twin-screw, (3) counter-rotating twin screw, and (4) Woodtruder™.

Single-Screw Extruder, Advantages of the single-screw extruder are that it is a proven technology and this method has the lowest capital acquisition cost. While it has lower output rates, an additional drying system is required, the polymer is melted with the fiber with greater risk of fiber thermal decomposition, high screw speed (rpm) with greater risk of burning at the screw tip, and inability to keep melt temperature low with higher head pressures.

Counter-Rotating Twin-Screw Extrusion has a low screw speed (rpm) and low shear mixing, and it is a proven technology. However, a drying system is required, a size reduction system for fed materials may be necessary, a pre-blending system is required, and material transportation can impact the mix feed ratios.

Co-rotating Twin-Screw and Hot Melt Single-Screw Wood Composite System, it can process wood at ambient moisture content since the extruder is used to dry the fiber with the elimination of drying and pre-blending operations, and good fiber/polymer mixing. However, it needs for peripheral feeding systems, high screw speed (rpm) and no screw cooling (greater risk of burning), inability to keep melt temperature low with higher head pressures, and polymer is still melted with the fiber (greater risk of burning, more difficult to vent).

Woodtruder, it includes a parallel 28:1 L/D counter-rotating twin- and a 75-mm single-screw extruder, a blending unit, a computerized blender-control system, a die tooling system, a spray cooling tank with driven rollers, a traveling cut-off saw, and a run-off table. In this type of extruders, the flour and additives are in their natural states and no material preparation is required. Gravimetric feeders are preferred as the material feed method. It has ability to process fiber at the ambient moisture content (5-8%), the separate melting process of the polymer, good polymer/fiber mixing, screw cooling is included on the twin-screw, the ability to maintain a

low melt temperature with high head pressure, superior venting, the elimination of drying, size reduction and separate pre-blending equipment, highly flexible integrated process control system for material feeding, and extruder. unit operations. However, it includes lower product throughput, higher capital costs, and using the main extruder as a dryer is not the most efficient manner to process dry flour of wood.

Miscellaneous Post-extruder Unit Operations, along with the extruder, the die is an important part of the WPC profile extrusion system. The die dictates the dimensions and profile (shape) of the extruded part. The die is typically heated using band or cartridge heating elements and may employ air-cooling to adequately process hollow profile parts. Dies can be quite simple or complex depending on the desired profile. After the die, comes the cooling tank, which is used to freeze the extruded profile in its linear shape. The cooling tank consists of a conveyor system with water spray heads that spray cool water on the profile extrudate. The cooling tank maybe 6 to 12 m long depending on the extruder material output and the cooling capacity required. The water spray is typically recycled and may go through a chiller or heat exchanger to keep the spray water cool. After the cooling tank, the WPC profile goes through a cut-off saw that can cut the lumber to the desired lengths.

So, the most commonly used method of creating Wood-Plastic-Composites is through extrusion. This process is characterized by the use of extruders and dies to form the composite into sheets, as the machine's motor, extrusion machine, turns a screw that feeds the composite through a heater. The granules in the composite melt into a liquid, which is pushed through a 2D die opening tool. The second most popular method of WPC production is Injection Molding. Injection Molding relies on molding the composite that are used to form 3D shapes. While the third is Compression Molding or Thermoforming has been used extensively in the manufacture of automobile composite parts. It is based on the method of molten die casting and consists of the clamping unit and the injection unit. While both commonly used methods, the process is expensive as the physical impurities of the recycled materials cause tears in the die, and thus requiring constant maintenance or replacement [13]. The production of WPCs using the injection molding method is shown in **Figure-7**.

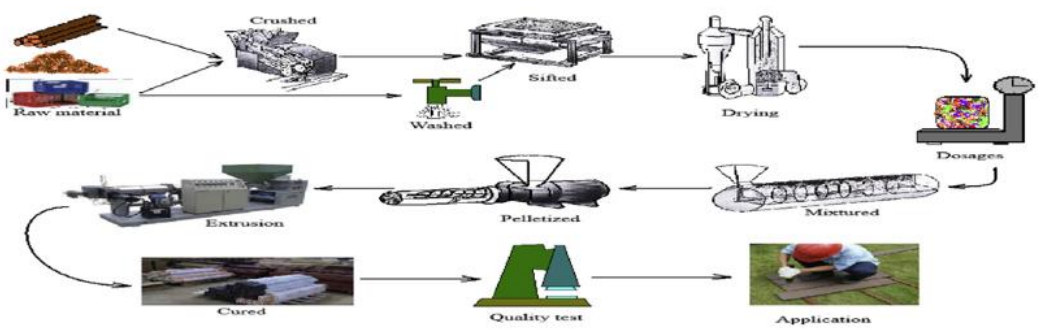


Figure-7: Wood-Plastic-Composite Process [10]

Due to the expenses associated with the extrusion method, industry leaders have made attempts to find other techniques to create the composites. One method that initially seemed to replace the extrusion technique was Stir Casting. Stir casting is comparatively more economical and an easy way to fabricate the metal matrix composite [14]. However, this method failed to replace injection molding due to its diminished mechanical properties, as the tensile strength of the composite was one-third of the tensile strength created through other techniques [14]. This was largely due to the internal defects of its product, such as blowholes, honeycombs, and cold shuts, which were highly detrimental to the structural integrity of the composite.

Another promising method that has the potential in the forming process is press forming. The composite is formed at a high temperature and die cut. This combination of forming and cutting is vital as the cutting process is much more efficient when the composite is at its forming temperature. While the problem associated with the pressing method is the repeatability of the cutting process, which is defined as the variation of dimensions measurements of the output from the same process. The mechanical properties of the WPC product using this method are highly reliant on two significant parameters: formation temperature and the dwell time of the mold. Ideally, the forming temperature should be above the melting point, and the dwelling time should be between 5 to 10 seconds. Shorter dwell times result in a warped and curved geometry and increases defects in the composite. Results show that the thickness of each measured section varies between 2.5 to 2.54 mm [9]. The challenges associated with maintaining each parameter are shown in **Table-1.**

Challenge	Result
Forming Temperature	Setting the temperature at melting point and temperature control during the process
Dwell time	Defining minimum acceptable dwell time in accordance to material property

Table-1: Challenges in Pressure Forming [13]

The effect of the forming temperature on the composite is shown in **Figure-8**

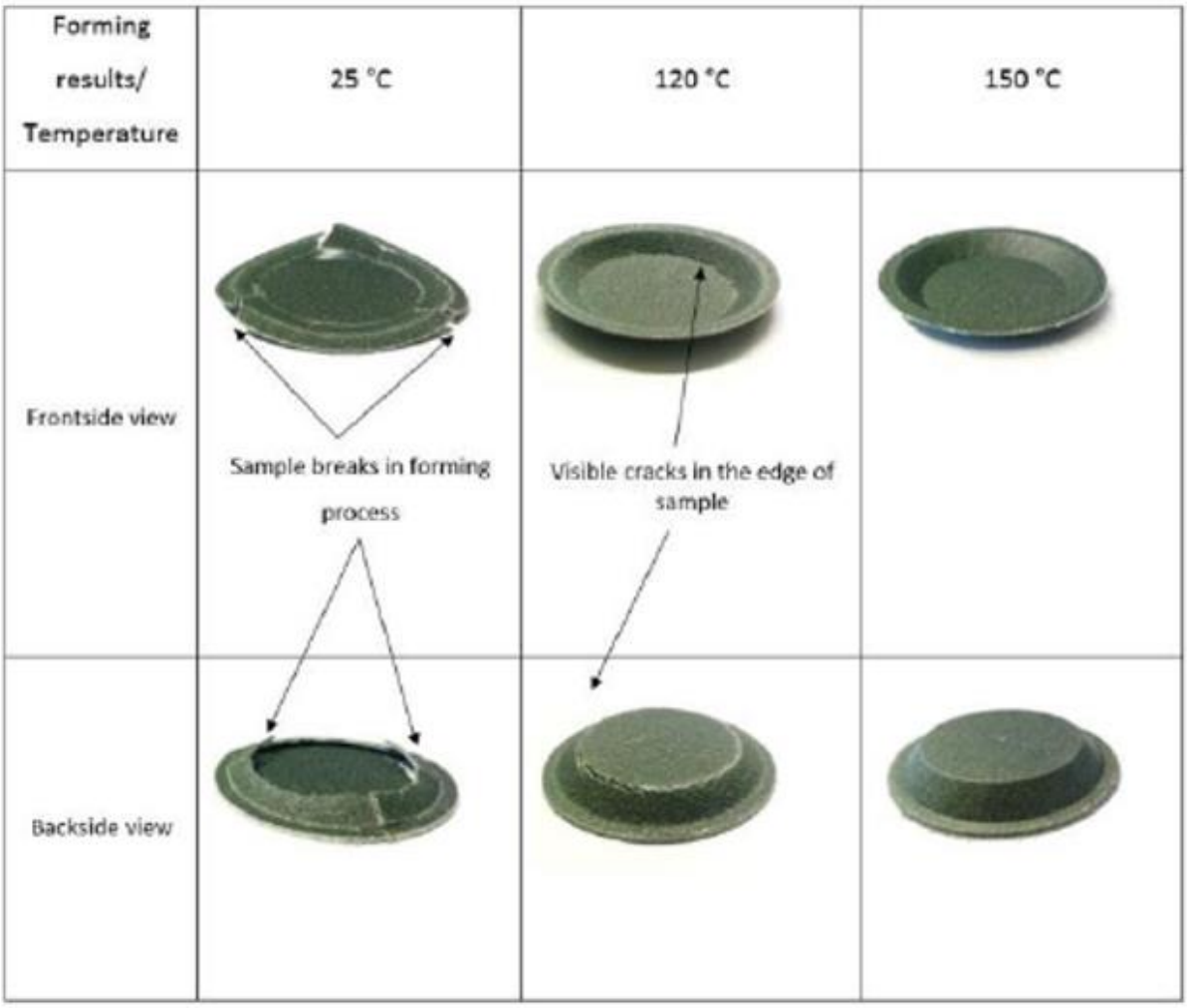


Figure-8: Effect of Temperature on Wood-Plastic Composite [13]

2.4.2. Raw Materials and Additives in WPC Production

As mentioned earlier, one of the main advantages of WPC products is their use of recycled and wastage materials in production. These materials can otherwise be harmful to the environment if stored in landfills. One example is sawdust, which is one of the main residues from wood processing. When improperly stored, sawdust can be a major source of environmental pollution, due to NO_2 emissions which could have adverse effects on the human respiratory system [10]. Another example is plastic, which due to its over-use, has become a major global pollutant [10]. Other methods of disposal of these pollutants, such as burning/ incineration can have similar adverse effects due to the release of harmful toxins into the atmosphere.

Composites are primarily composed of a combination of synthetic or natural materials of two or more differing physical and chemical properties. In most cases, wood flour, a component obtained from sawdust residues, is used to prepare the organic filling of the

composite [5] to improve its mechanical characteristic. **Figure-9** shows the impact of wood percentage on the Modulus of Elasticity (MOE).

Figure-9 Shows the impact of wood per centage on the Modulus of Elasticity (MOE).[26]

Commonly used inorganic fillers are talc, calcium carbonate, mica, kaolin, feldspar, aluminum hydroxide, and fiberglass which were used to reinforce the plastic products while it impacted the composite wight. **Figure-10** shows the different impacts between the reinforced fellers on the composite weight.

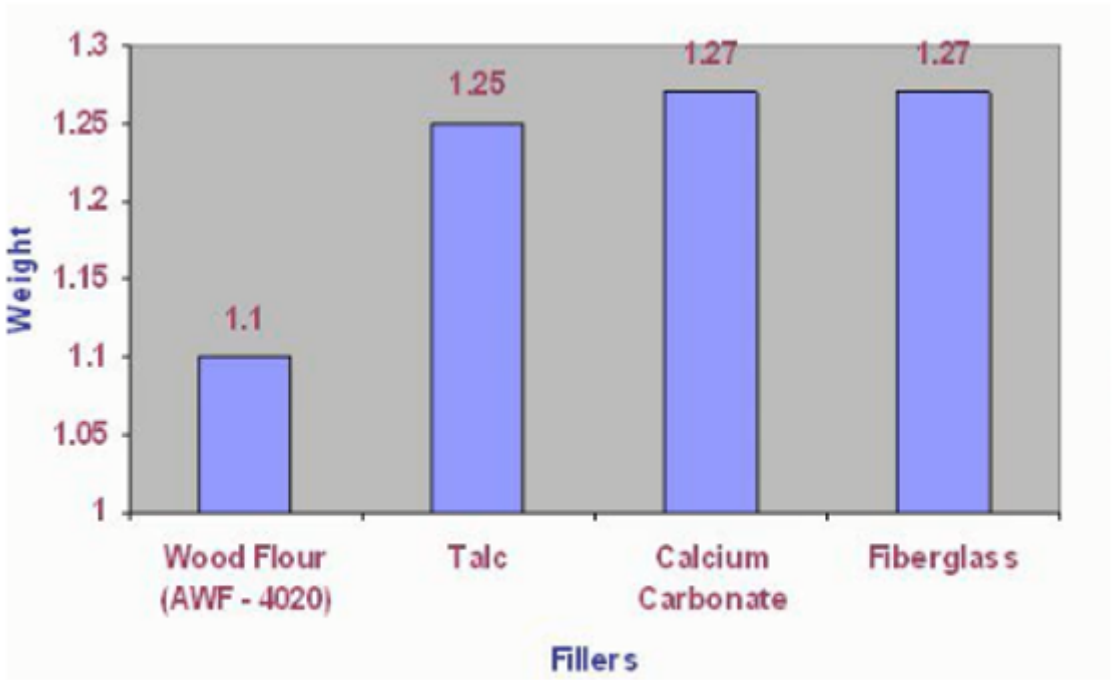


Figure-10: The different impact between the reinforced fellers on the composite weight on the composite weight.[26]

In addition to wood and plastic, WPC production requires additional materials that can give the composite better mechanical and chemical properties. Some of these additives include lubricants, colorants, ultraviolet stabilizers, and flame retardants, while the most important additive is the coupling agent, which allows for the adhesion between the fiber and matrix **[11].** Fibers increase the mechanical properties of the composite, while the matrix distributes the applied load on the composite uniformly and transfers this applied load to the fibers. Based on the application, other agents can also be added. The thermoplastic components such as PVC (Polyvinyl chloride), PP (Polypropylene), and PE (Polyethylene), for example, improve the moisture-resistant properties of the composite. For outdoor applications, the weathering properties of the WPC product are a detrimental factor in its durability. This is because the absorption of water by the wood surface causes the composite to swell, thus leading to a degradation in the component's mechanical properties. The use of coupling agents as an additive reduces water absorption and thickness swelling enormously, and as a result contributing to increased durability and dimensional stability **[11].** Two types of coupling agents that are currently in use are maleic anhydride (Coupling Agent 1) and isocyanate (Coupling Agent 2) **[19]**. A study conducted by Min and Shuai compared both agents and found that isocyanate was the superior coupling agent **[19]**. The study used four different polymers: Polypropylene (PP), Polystyrene (PS), Polyethylene (PE), and Acrylonitrile-butadiene-styrene (ABS). Furthermore, the study compared various mechanical properties of the four polymers, such as the Modulus of Rupture (MOR), the Modulus of Elasticity (MOE), and the Thickness Swelling (TS). The results of the study are shown in **Figures-11.**

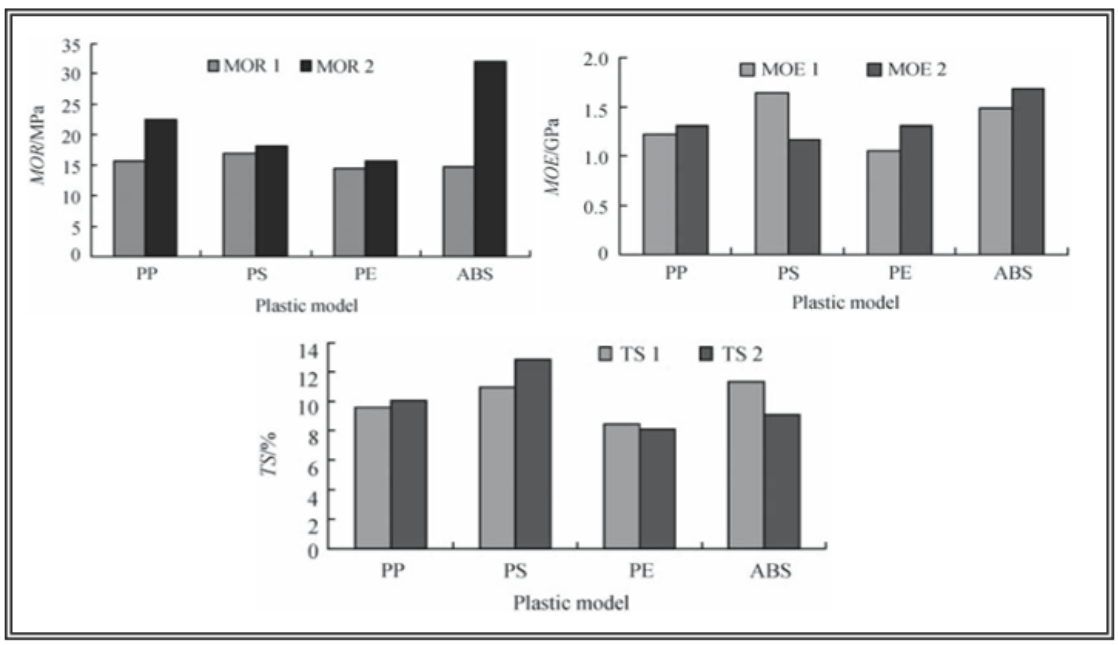


Figure-11: Comparison of Coupling Agents for Different Polymers **[19]**

Another material that can be added to the composite to improve its properties is rubber, which leads to the formation of rubber-wood-plastic composites (RubWPC). The bonding of such a composite can be improved through MAPE, Si69, and vinyltrimethoxysilane (VTMS) coupling agents [12]. These coupling agents improve the bonding between rubber particles and WPC components, leading to a 57.1% increase in tensile strength and a 20.7% increase in the tensile modulus [12]. RubWPC is expected to become a leading product in the construction sector due to its high durability, lightweight, and improved mechanical properties. To improve productivity, pigments or lubricants can be used as they increase the throughput rates and allowing for an easier extrusion process when mixes are vicious [18].

The mechanical properties of WPC are largely affected by the proportions of its components. Composites with a sawdust proportion above 50% (by weight) have low mechanical resistance and diminished physical properties [10]. The ideal mixing proportions for WPC can be seen in **Figure-12.**

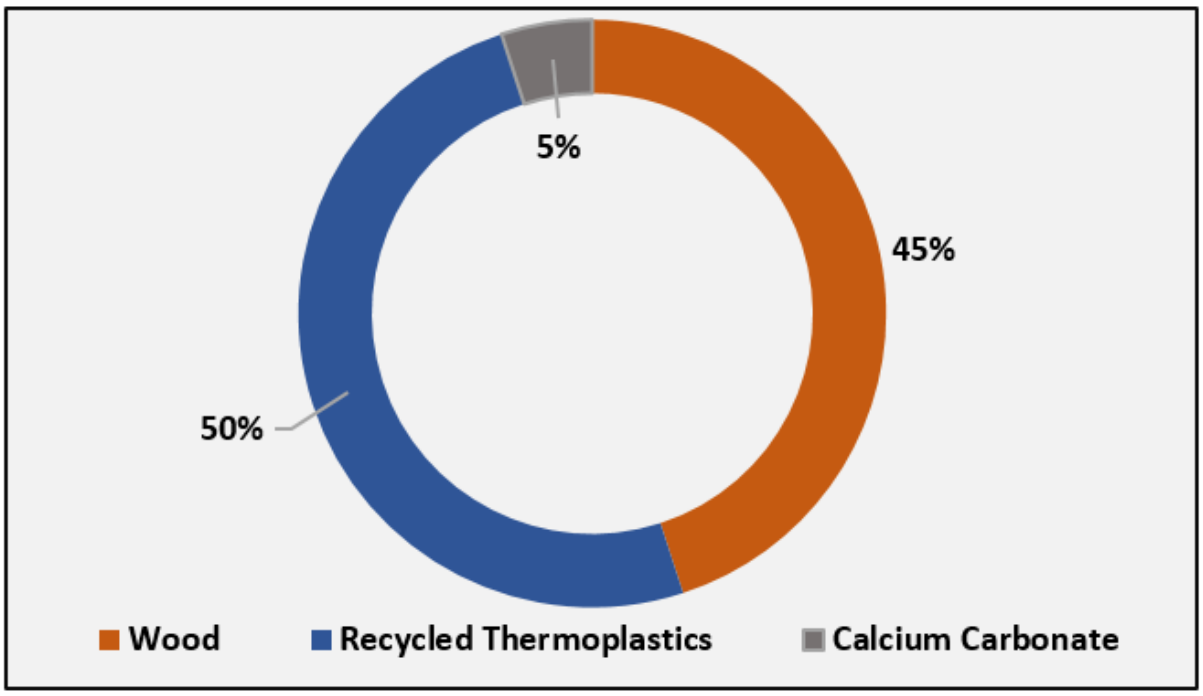


Figure-12: Mixing Proportions for Wood-Plastic-Composites [10]

An interesting benefit of using WPCs is the similarity of the mechanical properties between composites that use recycled resources and those that are made from virgin resources [20]. This is highlighted in **Figure-13.**

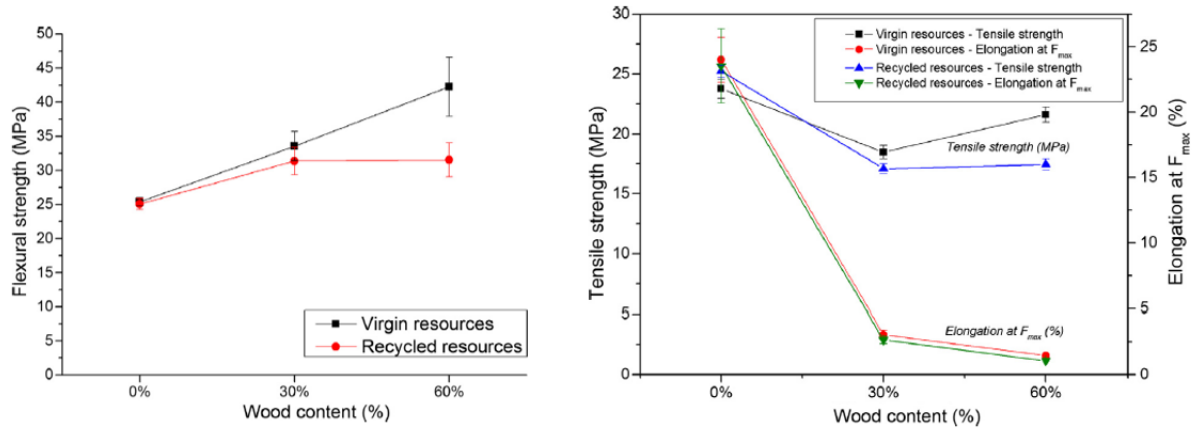


Figure-13: Mechanical Properties of WPCs based on resources used [20]

The types of additives [24] used in the WPC industry include lubricants and rheology control additives, coupling agents, stabilizers, fillers, density reduction additives, biocides, product aesthetics additives, flame retardants, and smoke suppressants.

The effects of lubricant content they found the apparent viscosity decreased by increasing the lubricant content. An optimal amount of wood fiber, HDPE, **maleic anhydride polyethylene** (MAPE), and lubricant can facilitate the processing by reducing viscosity and maintaining the mechanical properties and surface smoothness. A lot of tests on the material have been applied to determine the more suitable lubricant such as **ester, zinc stearate, and Biocides**. The ester-type lubricant enhanced the dispersion of maple particles and provided good external lubrication.

The effect of using biocides in the wood composite leads to reduce the weight loss of the wood component in the WPCs caused by brown rot fungus compared to natural wood. **Na/Ca borate** performed marginally better than **zinc borate**. While others try to use (**silver and zinc**) at three concentrations to treat WPCs made from wood flour and HDPE. Overall, the **zinc biocide** controlled the fungal growth and discoloration effectively as well. In contrast, the silver biocide did not inhibit the fungi or discoloration, which was deemed inefficient.

The effect of using stabilizers to reduce the UV effect. **Ultraviolet** (UV) light will cause discolor and lose mechanical strength gradually. To overcome this durability issue, stabilizers like **hindered amine light stabilizers** (HALS) and ultraviolet absorbers (UVA) were applied to WPCs. Diester HALS can stabilize the color of WPC by scavenging the free radicals generated by UV exposure. The higher the molecular weight of the diesters, the better stability it had in the composite. While when combining **benzotriazole UVA** and **diester HALS together**, they found that UV stabilizers reduced the photodegradation of the WPC, however, did not appear to affect the mechanical properties.

The use of compatibilizer, a compatibilizer system consisting of a paper wet-strength agent polyaminoamide–epichlorohydrin (PAE) and stearic anhydride was investigated for wood/PE composites. Results indicated that the system increased the modulus of rupture (MOR) by 33% and modulus of elasticity (MOE) by 40% compared to pure wood/PE composites. Also, the additive system performed better in MOE though a slightly lower MOR was obtained compared to the composites treated with MAPE. The same authors studied another system made by polydiphenylmethane diisocyanate (PMDI) and stearic anhydride for wood/PE composites. The MOR and MOE of the composites were both significantly higher than MAPE treated ones. The improved MOR and MOE arise from the improved interfacial adhesion and enhanced wood particles.

Foamed WPCs have favorable properties like reduced weight and cost, increased impact strength, strength-to-weight ratio, and surface definition (sharper contours and corners). Three types of chemical foaming agents which called blowing agents (**endothermic**, **exothermic**, and **endothermic/exothermic**) were added to mixed wood fiber and PP granules and then injection molded. Considering cell size, diameter, and distance for the micro foamed composites, exothermic foaming agents were the best ones to produce foaming in a PP matrix. The density of the WPCs was reduced by nearly 30%, and there was up to a 70% decrease in surface roughness.

Toughening agents were adopted to improve the reduced impact strength caused by adding wood fibers into polymer matrices. **PHA** was found to increase the impact strength of wood/PLA composites but compromised tensile strength and thermal stability. **Styrene–butadiene–styrene** (SBS) block copolymer can also improve the impact resistance and elongation at the break at the expense of tensile strength. No significant effect on the thermal stability of WPCs was caused by this toughening agent. Plasticizer was investigated in WPCs as well. It can reduce the increased glass transition temperature (T g) caused by adding wood flour into the polymer matrix thus facilitates the manufacturing. Wood flour/LDPE composites had reduced viscosity and less extrusion torque during processing. It displayed better elongation property when plasticizers were applied.

2.4.3. Durability and Improving Endeavors

The durability of wood–plastic composites falls under two categories [21]: structural and aesthetic durability. Structural durability is most important from a safety standpoint for building structures made using WPCs, but aesthetic durability which is Mold and mildew, and color fading of WPCs tend to be the durability issues.

Wood fibers are hydrophilic because of the hydroxyl groups contained in the cellulose and hemicellulose molecular chains. However, most thermoplastics employed in WPCs are hydrophobic. Wood fibers will agglomerate during compounding attributed to hydrogen bonding. As a result, the wood may not be well dispersed in polymer matrices, and therefore, its reinforcing effect can be compromised. The mechanical properties of plastics can be degraded in some instances when aggregation occurs. Thus, modification of the wood fiber is very critical to making improved WPCs.

It is noted that the influence of fungal decay on the physical and mechanical properties of WPCs. The fungal can be controlled by adjusting the ratio of wood to plastic in the composite formulation. And the type of wood species can determine the weathering performance of WPCs. For instant, hybrid poplar and ponderosa pine which is light-colored woods exhibited better color stability, so the use of durable wood species in WPCs led to improve durability performance. The weathered WPC surfaces can be analyzed using infrared and X-ray photoelectron spectroscopy and contact angle analysis. It was determined that the oxidation and degradation of lignin influenced WPC color changes during weathering. The use of Co-extruding additional opaque coating on WPCs improved the resistance to color changes. Also, the thermal treatment of wood particles has been shown to improve the dimensional stability of WPC panels. It found that weathering caused polymer matrix cracking because it exposed to UV and wood–matrix debonding contributing to increased moisture uptake in the WPCs. And subject to fire retardancy studies, it was determined that decabromodiphenyl oxide, magnesium hydroxide, zinc borate, melamine phosphate, and ammonium polyphosphate improved the fire performance of the WPCs, fire retardant is important if they are designed for furniture and residential building applications.

Thermal treatment of wood refers to a process where wood fibers are conditioned with heat and moisture at a temperature around 230°C to produce an inert surface and eliminate hemicellulose. The mechanical properties of the composite were enhanced significantly. Flame spread, specific gravity, and thermal expansion remained the same after the treatment. Tensile strength and thermal stability were found to be increased by the extraction process. Water absorption and thickness swelling of the composites made by PP or HDPE were reduced after hot water extraction.

Energetic Treatment, Atmospheric glow discharge (AGD) was a technique using high-voltage radio frequency with industrial plasma. The advantage of AGD is it can treat the surface with gases at atmospheric pressure. The flour of wood was treated with AGD where the surrounding gas was hexamethyl di-siloxane. The treated wood flour dispersed evenly in the PP and had better interfacial bonding with the matrix. Corona treatment was conducted on both

wood fibers and PE matrix to improve interfacial bonding. As a result, a significant increase in strength properties and ductility of the composite was observed.

Chemical Treatment, besides modifying the hydrophobicity of wood fibers, chemical treatments can add functional moieties to wood fibers by reactions with their surface functional groups. The modified wood surface will have improved interfacial bonding with polymer matrices. Coupling agents are chemicals that have two different functional end groups. One group is used to react with the hydroxyl group of the wood fiber while the other is used to interact with polymer matrix. More than 40 types of coupling agents have been investigated to modify wood fibers, and the most popular ones are **isocyanates, anhydrides, silanes, and anhydride-modified copolymers**. Two **maleic anhydrides grafted polypropylene** (MAPP) copolymers of different molecular weights were used to treat wood flour to make composites with PP. MAPP with a larger molecular weight contributed more to the composite strength improvement. MAPP with a smaller molecular weight improved processability significantly. **Vinyl trimethoxy silane** at different concentration levels was added during the compounding process by a twin-screw extruder. The resulting wood/HDPE composite had increased toughness, impact strength, and creep properties, while the flexural modulus was lower. Those changes resulted from the fact that the polymer matrix in the silane-treated WPC exhibited lower crystallinity. **Benzylation** was found to decrease the water absorption of WPC but inversely affected the interfacial adhesion. Two surfactants (**stearic acid and cellulose palmitate**) did not improve the tensile strength of WPC, but they were beneficial to the homogeneity and processability of the composites. Alkaline treatment was found to improve the dispersion of wood flour in PP. The treatment slightly increased mechanical properties. **Acetylation** of the wood was applied to improve the incompatibility between wood fiber and HDPE. This treatment improved interfacial adhesion and tensile modulus, whereas the strain at failure decreased. Esterification (**acetate, propionate, benzoate**) was used to treat poplar wood fibers. The resulting wood fiber/HDPE composites had better mechanical properties, improved resistance to fungi, and enhanced weathering performance.

For the product standards, in the USA, construction products are ruled by building codes that specifies the minimum acceptable levels of safety for constructed objects. Most WPC products in the USA are utilized in building materials with few exceptions for residential and commercial building applications. The International Code Council (ICC) has historically developed a major model building code. In the past, WPC and plastic composites have not been addressed directly in the building code. However, as of 2009, the International Residential Code (IRC) added WPCs to the code. Under these criteria, materials are evaluated for their stiffness,

strength, and ability to withstand environmental factors such as termite damage, decay, and fire performance.

In addition to the research being done to develop new methods of WPC production, studies are also being undertaken to develop its mechanical properties. The strength of WPC products is heavily dependent on the interlinkage between the natural fibers and the matrix. Other contributing factors are wetting and the degree of fiber distribution across the matrix which can influence the flexural strength of the composite [2]. In recent studies, Chinese fir (Cunninghamia lanceolata) waste was used as reinforcing material and low-density polyethylene was used as a matrix. Maleic anhydride grafted polyethylene octene elastomer (MPOE) and octadecyl organically modified montmorillonite (OMMT) were used as compatibilizers [2]. The product was tested using the SEM, FTIR, and mechanical tests, and showed improved mechanical and physical properties. In fact, the tests have shown a 41.46% increase in the tensile strength and a 26.89% increase in the impact strength [2]. The aforementioned study demonstrates how the addition of compatibilizers is a cost-effective choice in the production of WPCs as they are relatively cheap and can lead to massive improvements to the physical properties of the composite.

One detrimental factor that affects the surface strength of Composites is UV radiation. Wood contains approximately 50% cellulose, 23-33% lignin and 5-30% extractives [5]. UV radiation causes photochemical degradation to composites, as it affects the lignin present in the wood components, reducing its structural integrity and giving rise to color changes. In addition to photodegradation, outdoor WPC products that were subjected to UV Radiation experienced cracking, lower water resistance, and surface erosion [6]. This reduces the service life of the product. To combat this, chemical treatment of the wood component is required. Some examples of currently utilized methods of treatment include heat treatment, corona treatment, plasma treatment, silane treatment, alkaline treatment, acetylation treatment, malleated coupling, or enzyme treatment [5]. The most commonly used method is a heat treatment which improves water resistance, enhances bio-durability, and increases the color stability of the composite. Research shows that Heat-treated Wood-Plastic-Composites (HTWPC) exhibit shallower crack formation, higher durability against erosion and have a smaller initial discoloration [6].

Another affecting factor to Wood-Plastic-Composites is moisture. In a study conducted by Machado, Santos et al, it was discovered that there is a strong negative linear relationship between water absorption and bending stiffness of the composite (between 40 to 50%) [17]. This stiffness loss can lead to a composite incompliant with the serviceability limit states, preventing it from being used for structure purposes.

2.4.4. Dealing with WPC Waste

As the production of WPCs is expected to increase, dealing with the industrial waste of WPC production is becoming a more significant topic of discussion. One advantage that Wood-Plastic-Composites have is that waste can be recycled and reprocessed several times [15]. This comes with drawbacks, however, as the mechanical properties of the composite progressively decrease due to macromolecular degradation [15]. After a certain number of reuses, the waste can no longer be reused as its mechanical properties are considered structurally inadequate. This presents a problem for the plastic components in particular, as the material is non-biodegradable. To solve this problem, recent studies have been exploring the implementation of energy recoveries technologies, such as pyrolysis. This process can convert WPC wastes into biofuels, giving a second life to the wastes instead of disposal [12].

2.5. WPC Market Insights

In the UK market [25] WPC is almost made of 60% wood flour, 35% recycled high-density polyethylene (HDPE), plus additives, including UV light absorbers, anti-oxidants, bonding, and coupling agents, lubricants, and colorings. Many wood plastics composites on the market use recycled high-density polyethylene (HDPE) to offer sustainability. However, impurities can cause quality issues with the product that may not be visible or noticeable initially at the time of purchase, but will after a couple of years show themselves. Therefore, they run many different batch tests at every stage of the process to ensure the purity of the recycled used material. Wood-plastic composites are made in much the same way as standard plastic extrusions, the main difference being that with wood-plastic composites the molds have a shorter life expectancy, so molds have to be replaced on a regular basis to keep the profiles nice, clean, and sharp.

Many people regard weight to be a good thing. If something feels heavy it must represent quality. In fact, in terms of wood-plastic composites, lighter is better. Heavier wood-plastic composites will contain a higher amount of filler, such as calcium carbonate. Calcium carbonate specific gravity is over twice that of both the wood and the HDPE. They use calcium carbonate for firstly, it increases the weight and, just like plastic in its raw form, wood plastic composite is traded by weight. Making it heavier allows you to sell less for more. Secondly, calcium carbonate is used to give a higher tensile strength in test reports. The negative aspect of this is that while the composite gains tensile strength, it loses its flexibility and becomes more brittle. Problems occur when rainwater saturated with CO2 meets the calcium carbonate. A reaction takes place where calcium bicarbonate is formed. Calcium bicarbonate is water-soluble and, therefore, allows water to penetrate the material, which will cause material

degradation. Laboratory tests normally use pure water (not saturated with CO2), which will result in inaccurate test result data.

Increased wood to the plastic ratio: This is a very common ‘cheat.’ The wood in the composite is one of the cheapest ingredients, while the plastic is one of the most expensive and makes up the majority of the cost. Increasing the wood content will give a composite that has a slightly ‘powdery’ feel. It will be less strong and will chip more easily than others with a higher plastic ratio. You might see severe chipping when cutting a board containing a higher proportion of wood to plastic.

Softwoods are softer and less durable than hardwood and are, therefore, prone to absorb more moisture than hardwoods. Low moisture content and absorption is critical to the performance of a wood plastic composite. To make a high-performance composite, it is critical to use a dry flour of hardwood. while using Bamboo in WPC does very much the same job as hardwood in the wood plastic composite. However, Bamboo has a very high moisture content, which takes a lot of energy to remove. Bamboo is also susceptible to mildew and many composites that use bamboo will blacken from mildew growth over time. This is due to a starch held in the bamboo.

Appendix-3- Marketing Study and Plan

3.1. Purpose of Market Study

- Looking for the Wood-Plastic composite products opportunities in Middle East market and selecting the attractive market in the Middle East.
- Conducting a competitive analysis which aims to support business decisions.
- Creating a list of competitors and creating a profile for each competitor that includes information such as the types of products and services they offer, marketing strategies, and notable strength and weakness.
- Allowing managers to exploit weaknesses, emulate strengths or avoid competing in areas which others are especially strong.
- Uncovering the market threats and opportunities by following the 5Cs and 4Ps principle:
  - Context
  - Company
  - Customer
  - Competitors
  - Collaborators
  - Product
  - Price
  - Promotion
  - Place

3.2. Product Introduction

Wood/plastic composites (WPCs) are types of reinforced plastic using wood particles such as wood flour or fibers. They do a mixture of wood flour and thermoplastic resins, such as polypropylene (PP), polyethylene (PE), or polyvinyl chloride (PVC). WPCs can be fabricated from environmentally friendly materials, such as wood waste, unused natural resources, and recycled thermoplastic resins. WPCs have many excellent properties such as high durability, specific strength, specific stiffness, and resistance to wear. They also have high molding performance and a texture similar to that of solid wood. The main application of WPCs is in the manufacture of exterior decking. WPCs can also be used in other industries, such as in furniture, internal decoration, siding, kids' toys, fencing, and cladding. WPC technology continues to mature as manufacturing processes improve.

As discussed previously during the review of literature, the first step in determining the need for WPC products is to analyze the economic value of its implementation. The sector first began gaining momentum in the 1990s, and the period between 1997 and 2000 saw the market of WPCs quadruple in growth [4]. By 2024, the global market of bio-composites is estimated to reach 8.2 billion by 2024 [5] with an estimated global compound annual growth rate of 9.3% during that period [6]. In Europe, market growth is expected to be even higher, with an estimated

annual growth rate of 10.2% [6]. The expected annual growth of the WPC revenue in Germany is demonstrated in **Figure-15.**

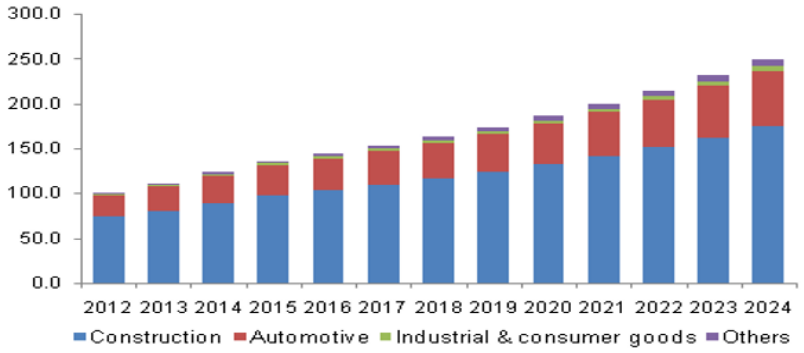


Figure-15: German Wood Plastic Composite market revenue, by Application (USD Million) [4]

Based on applications, **Figure-16** the wood-plastic composites market has been segmented into building and construction products, automotive components, industrial and consumer goods, and others.

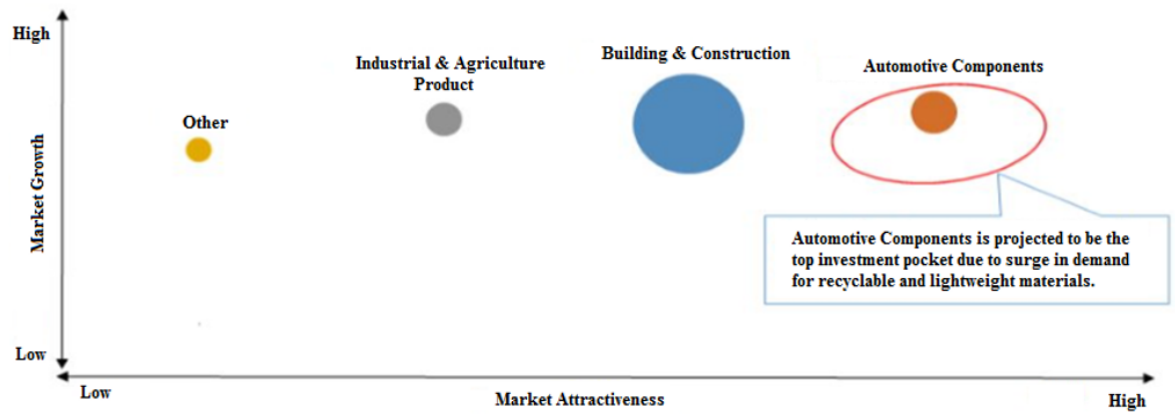


Figure-16: Wood Plastic Composite Market Segment

3.3. (Context), Market Status

Figures: 19, 20 and 21 show that the Egyptian is the most suitable market in MENA region for wood and its alternative product. The Egyptian market has shown an increased economic growth rate during the previous period, despite the political instability and the adverse economic effects of the COVID-19 pandemic. It is worth noting that in recent days a major economic transformation has taken place. The Egypt economy was considered as a governmental economy, however, nowadays there is a general trend towards privatization, which is considered to promise double economic growth in the coming interval. The government pays a great attention to the infrastructure, which is expected to follow a significant economic growth due to the geographical location and the trade agreements with the countries

in the region, such as African, European, and Arab countries. Tourism and industrial projects are expected to grow in Egypt **Figure-17** shows the growth rate [28] of domestic product (GDP) from 2015 to 2025, the market is booming and has an upward trend and despite the drop in 2020-2021 due to covid-19, it is still expected to recontinue booming.

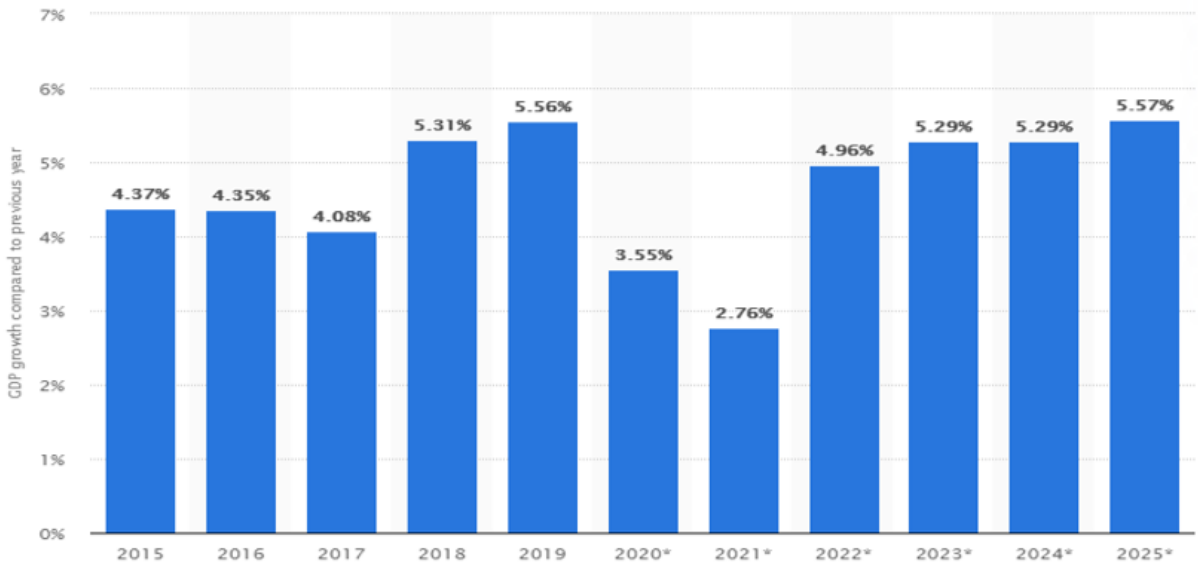


Figure-17: Gross Domestic Product (GDP) growth rate from 2015 to 2025

The population of Egypt, according to official statistics, in 2020 is 101.67 million, with an expected increase of approximately 2% annually, expected to reach 113.85 million by 2025. **Figure-18** shows the population histogram and forecast population until 2025. Egypt market is a promising market for the products and abundance of manpower as well.

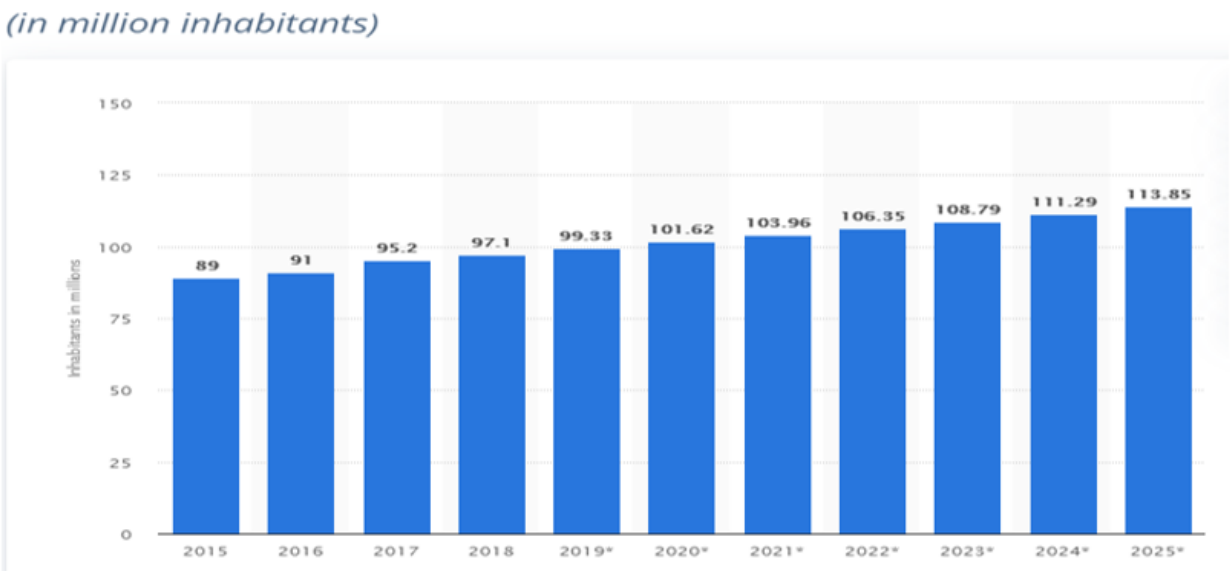


Figure-18 Egypt total population from 2015 to 2025.

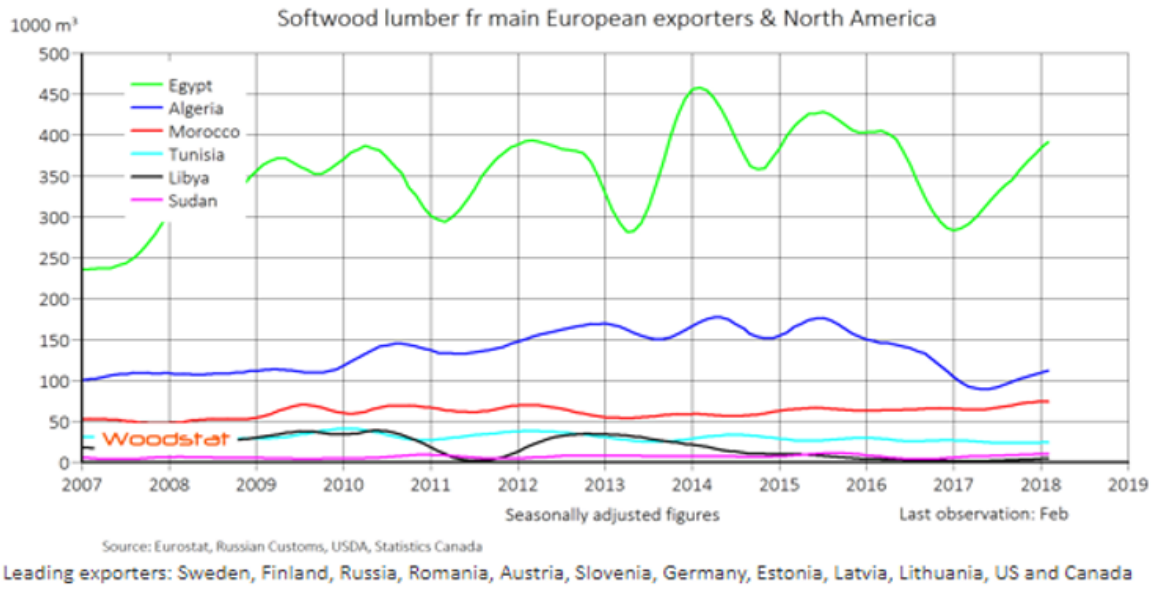


Figure-19 North Africa Monthly Import for softwood.

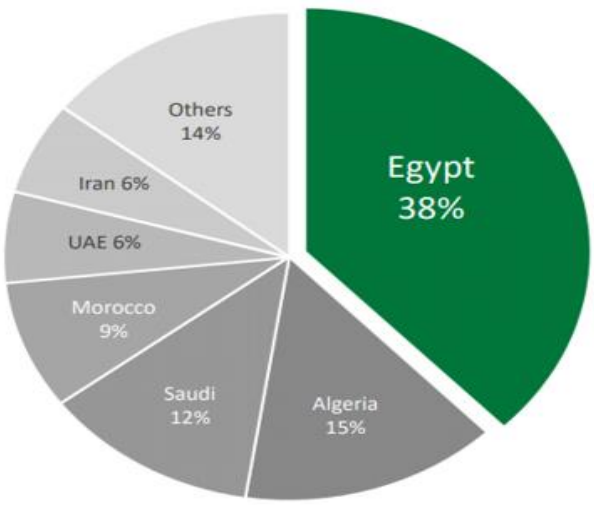


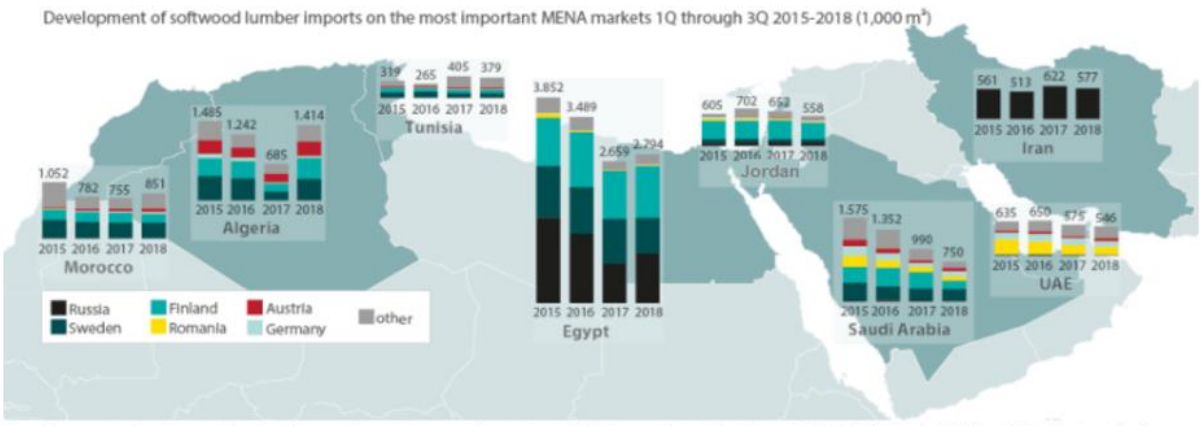
Figure-20 Mena softwood market in 2016.

Because wooden plastic composites are considered a new product to the Egyptian market, it is important to study other competing products currently available in the market. **Figure-19** [29] shows that Egypt is the leading African country in the consumption of softwood. This is also the case amongst MENA countries, as **Figure-20** shows that in 2016 Egypt has 38% of the MENA softwood import market shares. In 2019, Timber online [30] observed increasing volumes of softwood imports to the MENA region. **Figure-21** shows the MENA market of softwood from 2015-2018. Upswing for Egypt with 2.8 million m³, exports to Egypt compared to the same period in 2017 did show an increase of 5% – however, compared to the first three quarters of 2015 and 2016, the delivery volumes remained 27% and 20% respectively below

the "normal level". Despite a decline of 1 million m³ in four years, Egypt is still the most important destination – almost a third of MENA exports were delivered to the land of the Nile. From January to September 2018, 98% of the lumber came from Finland (970,000 m³), Russia (928,000 m³), Sweden (670,000 m³) as well as Latvia (166,000 m³).

Here are some highlights of the Egyptian softwood market:

- In 2015, Egypt imported 3.8 million m3, however in 2020 it reduced because of Covid-19 to 2.7 Million which still considers a big market.
- The biggest population in the MENA region. ~ 102 Million.



Development of softwood lumber imports on the most important MENA markets 1Q through 3Q 2015-2018 (1,000 m³) © Timber-Online

Figure-21 Development of softwood lumber imports on the most important MENA markets 1Q through 3Q 2015-2018 (1,000 m³) © Timber-Online

- No forests in Egypt.
- Fully dependent on imports to fulfill its need for softwood.
- The big & young population guarantees some kind of demand.
- A high density of population is concentrated in the Delta region.
- Doors and windows ~ 30% [31] of wood market.
- Furniture ~ 15% of the wood market.
- A wide variety of applications Flooring, Decoration, Shades, Packing, Kitchens, Block boards, and others.
- Egypt is in the middle of a promising wood market.

The majority of Egypt's population is located along the Nile river, as shown in **Figure-22.** The Nile Delta area is considered a big market for wood. The city of Demyate is considered as one of the citadels of wood furniture manufacture. Demyate city is located in the north-east of Egypt. Cairo city also is considered one of the biggest markets. The population of Cairo in 2020 was 20,901,000, a 2.03% increase from 2019. The population of Cairo in 2019 was 20,485,000, a 2.04% increase from 2018. In 2018 it was 20,076,000, a 2.18% increase from 2017.

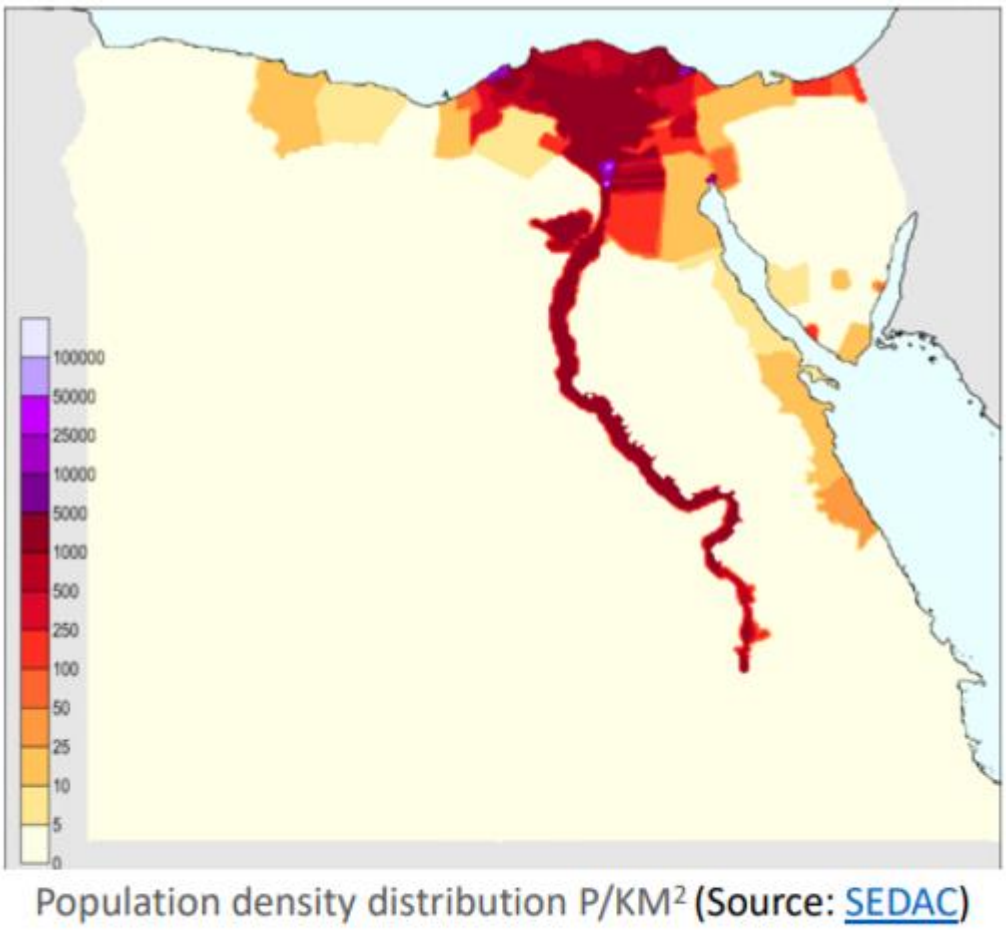


Figure-22: Egypt population density

The following analysis will summarize Egypt status from different aspects political, economic social technology, environments, and legal, which will help the decision-maker to determine its competitive situation.

3.3.1. Potential Market PESTEL Analysis

PESTEL Analysis					
P Political	**E** Economical	**S** Social	**T** Technology	**E** Environmental	**L** Legal
Governmental Policy: - Almost stable.	Economic Growth: -Has a rate of = 5.40 %	Population Growth Rate: -Rate= 0.06 %	Technology Incentives: -The government offers lower tax for new innovative products.	Weather: -Summer Max. Temp.= 45c -Winter Lower Temp. = 15c	Discrimination Laws: -N/A
Political Stability: -Not Stable Enough.	Exchange Rate: -Not stable =18.92	Age Distribution: 0-14 years: 33.29% (male 16,720,307/female 15,583,019) 15-24 years: 18.94% (male 9,464,262/female 8,919,614) 25-54 years: 37.6% (male 18,545,422/female 17,944,582) 55-64 years: 5.95% (male 2,861,136/female 2,911,586) 65 years and over: 4.22% (male 1,993,248/female 2,097,896)	Level of Innovation: -Intermediate	Climate: -Moderate	Antitrust Laws: -N/A
Corruption: -In acceptable limit.	Interest Rate: -Has a rate of = 16.75 %	Career Attitudes: -xxxxxxx	Automation: -Intermediate	Environmental Policies: -Not strict.	Employment Laws: -Not strict
Foreign Trade Policy: -Has a good agreements with African countries. -Has a good agreements with Europe countries.	Inflation Rate: -Has increased to a value = 13.2 %	Safety Emphasis: -Limited	R&D Activity: -In 2016 it has 7.2 % of GDP	Climate Change: -Steady	Consumer Protection Laws: -Very Week
Tax Policy: -Stable and have a good encourage advantages.	Disposable Income: -Has increased to a value = 990.00 EGP Billion	Health Consciousness: -Upper intermediate	Technological Change: -Limited	Pressures from NGO's: -Limited	Copyright and Patent Laws: -Very Week
Labor Low: -limited requirements.	Unemployment Rate: -Decreased to 9.9%	Lifestyle Attitudes: -Medium	Technological Awareness: -High		Health and Safety Laws: -Very Week
Trade Restrictions: -US dollar is unstable.		Cultural Barriers: -N/A			

3.4. Expected WPC Customers

- Residents of Egypt's Coastal area who incur regular maintenance costs due to weathering effects on wood. (windows and doors).
- Parks and resorts that are looking for decorative woodworks (cladding, flooring, and benches).
- Decorative companies.
- Carpenters who make floor, windows, and doors.
- Furniture manufactural companies.
- Exporting to MENA region and Europe countries.

3.5. Customer Needs

Customer are looking for floor material to cover the following needs:

- Weather-resistant.
- Splinter free.
- Cost efficiency.
- Timeless guarantee.
- Durable wood with less/no maintenance cost.
- Environmentally friendly.
- Fire retardant.
- Termite & fungus resistant.
- Non-toxic.

3.6. Alternative Material Suppliers in the Market

3.6.1. Alternative Suppliers' Products

- Resilient flooring.
- Ceramic tiles.
- Natural Wood.
- Laminate. (HDF)
- Marble.

3.6.2. Alternative Material Analysis

Resilient flooring:

Advantages	Disadvantages
• Easy to install. • Durable and low maintenance. • Water and Stain Resistant. • Comfortable underfoot. • Inexpensive.	• Potential toxic out-gassing (VOC). • Subfloor damage. • Susceptible to chemical stains. • Difficult to repair. • Not eco-friendly disposal. • Not fire retardant.

Ceramic tiles:

Advantages	Disadvantages
• Glazed tile is water and stain resistant. • Very durable and tough floor. • Low maintenance and refinishing. • Endless design options. • Fire retardant.	• Unglazed tie and need to be sealed. • Hard, cold surface to walk on. • Time-consuming meticulous install. • It is too heavy for upper stories. • Not heavy duty. (wearing problem)

Natural Wood:

Advantages	Disadvantages
• Natural material. • Readily available. • Low production energy. • Quicker and economical construction. • No thermal expansion. • Sound absorption. • High strength. • Easy maintenance and replacement. • Availability of various varieties of woods.	• Cannot be used in the construction of longer spans. • Shrinkage and swelling of the wood. • Biotic and abiotic deterioration of wood. • Irregular properties and gain varieties. • Stronger in some places than others. • Highly combustible. • Not fire retardant. • Not termite or fungus resistant.

Laminate (HDF):

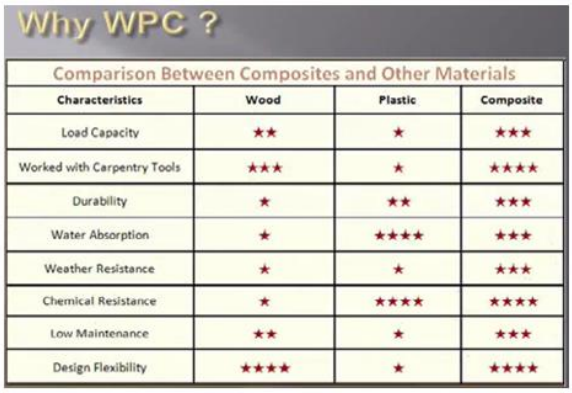
Advantages	Disadvantages
• Affordable price. • Laminate floors for bathrooms exist. • Ability to be installed in all rooms. • Many designs. • Easy installation. • Most popular floor. • Not Fire retardant.	• All laminate floors are not waterproof. • The floor has to be adapted to a frequent traffic or not. • Never clean a laminate with water. • Not heavy duty. (wearing problem)

Marble:

Advantages	Disadvantages
• Durable. • Easy to maintain. • Available in a wide range of colors and patterns. • Allergen and bacterial resistance. • Water and moisture resistant. • Elegant.	• Expensive. • Not easy to install. • Hard and cold underfoot. • Need regular cleaning, it stains easily. • Very heavy.

3.6.3. What is WPC can offer better than the alternative product?

Wooden-plastic composite:



Why WPC ?

Comparison Between Composites and Other Materials

Characteristics	Wood	Plastic	Composite
Load Capacity	★★	★	★★★
Worked with Carpentry Tools	★★★	★	★★★★
Durability	★	★★	★★★
Water Absorption	★	★★★★	★★★
Weather Resistance	★	★	★★★
Chemical Resistance	★	★★★★	★★★★
Low Maintenance	★★	★	★★★
Design Flexibility	★★★★	★	★★★★

Advantages

- Cost efficiency.
- Splinter free and durable.
- Environmentally friendly as it is natural wood recycles.
- Easy installation.
- Fire retardant.
- Natural wood look & feel.
- Weather resistant.
- Termite & fungus resistant.
- Non-toxic.
- Timeless guarantee.
- No need to paint.

Figure-23 shows the most common applications of WPC in Europe in 2012.

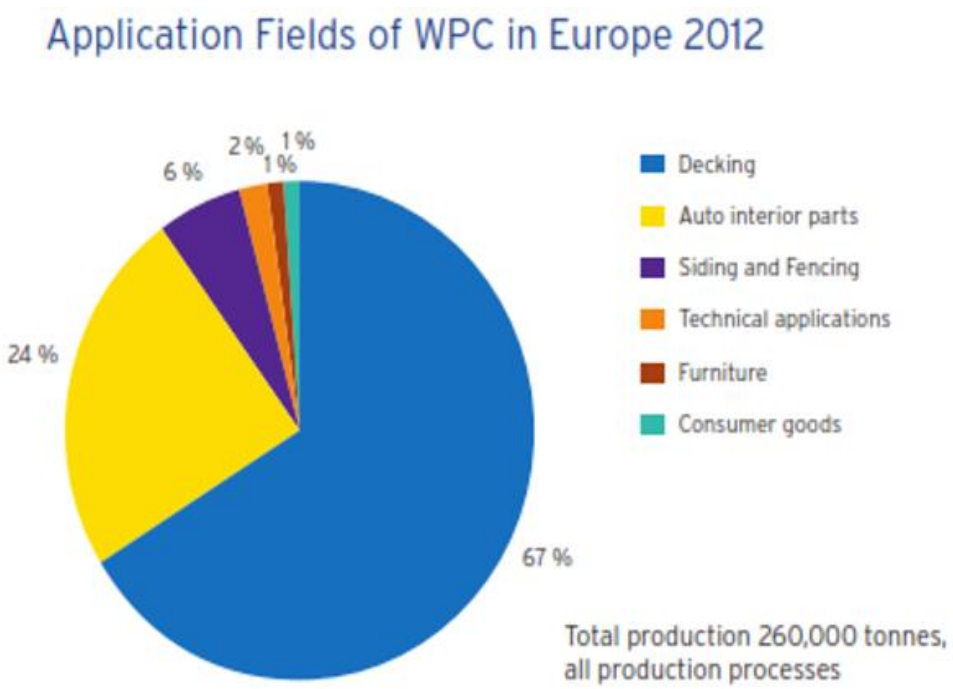


Figure 23: Application fields of WPC in Europe 2012

3.7. (Customers), Customer Analysis

Expected customers:

- **Residential application:** Customers looking for decorative works for their house (Roof Top Pergola and Cladding), Flooring, Windows, and Doors.
- **Municipalities:** Benches, and Pergolas in the public gardens.
- **Resorts and Clubs:** Decking around pools, Benches, Pergola, Cladding works, Windows and Doors.
- **Decorative Companies:** Decorative works
- **Restaurants and Retails:** Flooring and cladding work.
- **Furniture Manufacturers:** Using lumber.

End-use Customers are classified as:

- Residential use.
- Commercial use.

Customer Concerns with Substitute Products:

- Wood: While largely preferred by customers, the product is costly and requires high maintenance costs.
- Marble: Favored by Customers due to its aesthetic nature, but considered very expensive
- Ceramic: Not durable for commercial use and not aesthetically appealing compared to wood.
- Resilient Flooring: Not durable and has toxic emissions
- Laminate (HDF): Not durable and has problems with water absorption

What are customer's needs?

- The customers are looking for floor material to cover their below-mentioned needs:

• weather-resistant.	• Environmentally friendly.
• Splinter free.	• Fire retardant.
• Cost efficiency.	• Termite & fungus resistant.
• Timeless guarantee.	• Non-toxic.
• Durable material with less/no maintenance cost.	• Nice look.

Online reviews & References

In 2019, there were 23,603 wood plastic composite products offered for sale by suppliers on Alibaba.com [33], 46% of which were engineered flooring. In 2020, this number increased tremendously, with over 87,310 wood plastic composite products offered. This demonstrates the continuous increasing demand in the market, which attracts more suppliers to provide this product.

3.8. (Competitors), Available Suppliers of the Same Product

Egypt market shows limited market competition. Presently, there are two competitors, one is a manufacturer and the second one is a trader. The below-mentioned table shows the comparisons between available suppliers in the market:

Company	Value Added	Unique Aspects	Strengths	Weaknesses
"Our" Company/Brand	• Will offer a high-quality product. • Reasonable price. • Will consider a supply chain network, which will guarantee convenient product availability.	• Will offer a variety of product applications.	• Strong management skills will provide a competitive market position.	• Finance status.
Competitor-1 Hayawe Biowood [40]	• Offer design and installation work.	• Manufacture company.	• Well established company in the market since 2010.	• Weak in marketing with limited projects.
Competitor-2 EPOS EGYPT [41]	• Offer product with a high quality (Imported WPC).	• Trader company imports the product from another country.	• Trade company, selling different products.	• Very weak in marketing, very weak company website.

3.9. (Company), Strength and Weakness

3.9.1. What are we doing better than competitors?

- Product unique specification:
  - Weather-resistant.
  - Long-life guarantee.
  - Durable against wear and tear.
  - No maintenance.
  - No splinter.
  - Natural look and feel.
  - Easy to install or to remove.
- Well Educated management staff.
- A wide variety of product applications.

3.9.2. What are they doing better than us?

- They are a well-established company in the market.
- Customers are well familiar with their products.

We can summarize our competence in the market in the below-mentioned SWAT analysis:

SWOT Analysis			
S Strengths	W Weaknesses	O Opportunities	T Threats
• Professional Projects Management. • High Marketing Experience. • The product has a wide range of applications. • Product Qualities Unique specifications and Quality.	• Limited financial resources. • New company in the market. • High wastage material during production thresholds.	• Limited wood-plastic suppliers are available in the market. • Alternative products have a limited advantage over our product.	• Manpower stability. • Emerging Competitors: Will be in consideration. • The Customers are unfamiliar with the product. • Importing obstacles: -Long Procedure for importing raw material. -Fluctuating Currency Exchange rate.

Based on the above-mentioned collected market data we can establish TOWA analysis for the existing market strength and how we can benefit from it, and weakness and how we can turn to be opportunities.

TOWS Analysis		
	Strength (S)	**Weaknesses (W)**
Opportunities (O)	**Strength:** • Have a strong plan for marketing. • Have management skills to reduce the expenses. **Opportunities:** • WPC suppliers are limited in Egypt. Only one wooden-plastic manufacture is available in Egypt.	**Weaknesses:** • Limited Budget. **Opportunities:** • The Government gives good facilities for the new projects. i.e. free of tax, and the loans are with low interest.
Threats (T)	**Strength:** • Having a new product, which is difficult to imitate and it will take time for competitors to compete on the same product. • High usage of recyclable raw materials. **Threats:** • Market competition is very strong. • Currency change rate affects costs of imported raw material.	**Weakness:** • Limited experience with government legal or authority's procedure. **Threats:** • There is a barrier to entry from stakeholders. • Unclear government's requirement and long license procedure.

Based on the previous analysis, Egypt presents itself as a good market for WPC products. We can expect a high demand for Wooden Plastic products based on their advanced characteristics and the market demand for products with similar functionality. Furthermore, most of the raw materials are available in the domestic market, as well as other resources such as Labor & Electricity with can be obtained for a competitive global price rate.

3.10. Segmentation Analysis for Wood Plastic composite

3.10.1. Segment Types

3.10.1.1. Residential/ Private Applications

- **Furniture manufacture companies**; Using lumber.
- **Residence application;** whose are looking for decorative works for their house (Roof Top Pergola and Cladding), Flooring, Windows, and Doors.

3.10.1.2. Commercial/ Public Applications

- **Municipalities;** Benches, and Pergolas in the public gardens.
- **Resorts and Clubs;** Decking around pools, Benches, Pergola, Cladding works, Windows and Doors.
- **Decorative companies**; Decorative works
- **Restaurants and Retails;** Flooring and cladding work.

Figure-23 shows the approximate market share between residential and commercial use of WPC.

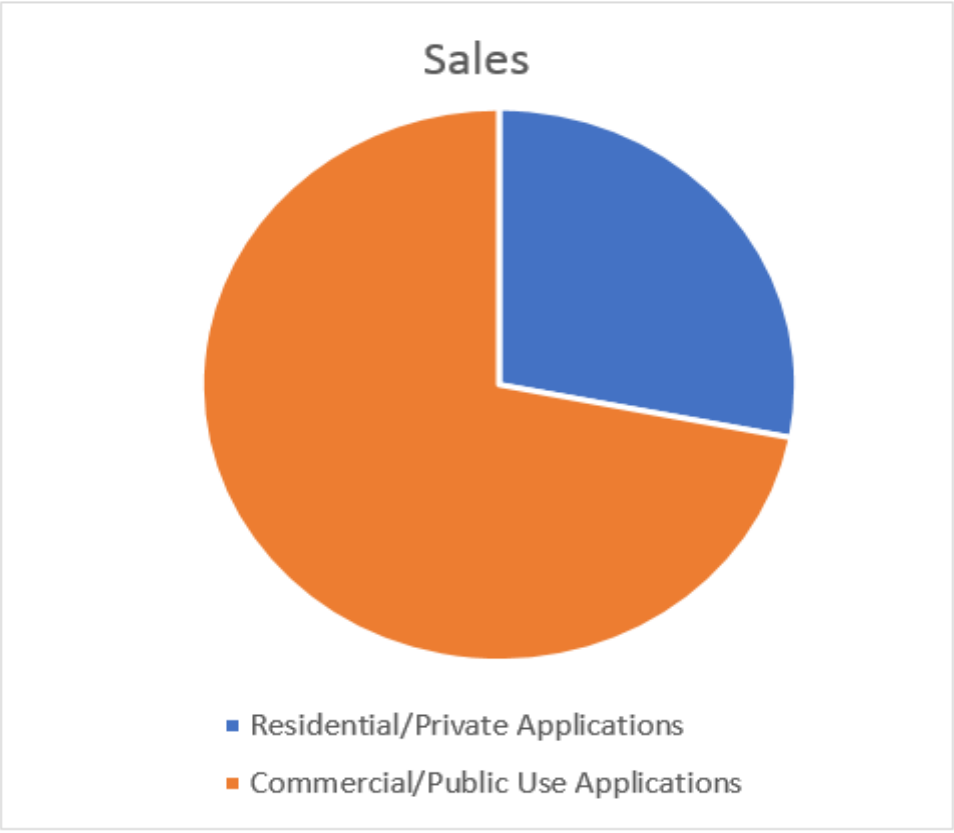


Figure-23 The WPC sales

3.10.2. Segment Analysis

3.10.2.1. Residential/Private Segment

Phase of Analysis	Segment Characteristic	Rationales
Who are they? What do they need?	• Furniture manufacture companies: ▪ Lumber to use in the manufacture of home furniture. • Residence application: ▪ Decorative works cladding and ceiling work. ▪ Roof Top Pergola. ▪ Flooring. ▪ Windows. ▪ Doors.	• Wide range of applications
What are the Buying patterns?	• Furniture manufacture company: Ongoing regular use. • Residential Home applicant: Occasional use.	• Stable Requirements
Where they get information?	• Furniture manufacture company: Direct approach sales. • Residential Home applicant: Advertising through online social media activity and newspaper.	• Initially costly to approach.
Brand loyalty Behavior:	• Furniture manufacture company: Depends on gained benefit, they can generate word of mouth • Residential Home applicant: They can generate a word of mouth. • Low price sensitivity.	• Easy to spread among the segment of customers.
Segment size:	• It will be considered to be spread among the Urban Population, whose are evaluated as 43.0 % [34] of population, whose are expected more consumable of product. • Annual growth rate 2.38% [35] (2018 est.)	• Attractive segment of 43 % of the total population.

3.10.2.2. Commercial/Public Segment

Phase of Analysis	Segment Characteristic	Rationales
Who are they? What do they need?	• Municipalities; Benches, and Pergolas in the public gardens. • Resorts and Clubs; Decking around pools, Benches, Pergola, Cladding works, Windows, and Doors. • Decorative companies; Decorative works. • Restaurants and Retails; Flooring and cladding work.	• Wide range of applications.
What are the buying patterns?	• They have a district pattern while in a good value contract. • Their purchases depend on the market economic situation.	• Profitable, while Risky depending on the economic situation.
Where they get information?	• Direct sales, salesman have to approach them.	• Easy to approach, and not costly.
Brand loyalty Behavior:	• Loyalty, depend on the quotation value and competitive offered price. • As it will be in public areas, so the product will be promoted themselves among other segments. • Low price sensitivity.	• More advantageous to spread among all segments.
Segment size:	• Current year 2020, GDP= 5.56%. • GDP From Construction [36] in Egypt increased to 65752.90 EGP Million in the fourth quarter of 2019 from 47384.30 EGP Million in the third quarter of 2019.	• Attractive segment growth rate 38.77%.

3.10.2.3. Segment Analysis Conclusion

From the above-mentioned analysis, we can conclude that we have Two Segments, which are:

A. Residential/Private Segment	B. Commercial/Public Segment
• Wide range of applications.	• Wide range of applications.
• Stable requirements throughout the year.	• Profitable and volume sales, while Risky depend on the economic situation.
• Initially costly to approach. (Advertisement cost)	• Easy to approach, and not costly. (Salesman approach companies and municipalities, no need for advertising activities)
• Easy to spread among the segment of customers. (Generated word of mouth)	• More advantage to spread among all segments. (It will be installed in public areas, so there is a chance for the product to promote itself)
• Attractive segment of 43 % of the total population. (Urban Population, as they attractive to the modern style and new innovations) • Annual growth rate 2.38% [35] (2018 est.)	• Attractive segment growth rate 38.77%.
• Low Price sensitively.	• High price sensitivity.

3.10.3. Target Segment in the Market

3.10.3.1. Target Market

- Commercial/Public Segment
- It is more in size, profitable, and more expected to be growth.
- It is a more strategic fit for the company.

3.10.3.2. Target Market Profitability

How Likely is the segment will be profit?

- The high volume of material consumption of the construction project will grantee a high profit.
- Low advertising costs will grant profitability.

How is the segment size and its anticipated growth?

- GDP From Construction in Egypt increased to 66,649.00 EGP Million in the fourth quarter of 2020 from 63,983.90 EGP Million in the first quarter of 2020.
- Attractive segment growth rate 4.16%.

3.11. Segment anticipated level of competition

Competitor-1: Hayawe Bio-wood

- Offer design and installation work.
- Manufacture company.
- Well established company in the market since 2010.
- Weak in marketing with limited projects.

Competitor-2: EPOS EGYPT

- Offer products of high quality.
- Trader company import the product from another country.
- Trade company, selling different products.
- Very weak in marketing, very weak company website.

What is the segment customer behavior and expectation?

- For commercial use they look for the quotation value and competitive offered price and delivery time it has a high priority. Then the product quality comes the second priority.

Does this market segment fit with who we are?

- Yes, as we are a factory local established, with mass production. So, we can help the volume requirement and delivery time, better than trading company whose imported product from outside.

Are we able to satisfy this segment?

- Company can deliver material on time, and satisfied the customer project schedule, especially for the urgent requirements.
- As a manufacturing company, we can produce a custom product for a unique specification it can relieve for specific projects. (i.e. we can offer fire-rated material with additional cost for those who asked for additional fire rated hours)

Can we attract this segment?

- Yes, the company will offer more product applications is not exist in the domestic market. Such as ramps, drums, fences, car park shade, beach chares, and tables.

What are our strengths?

- Professional Projects Management.
- High Marketing Experience.
- Have a wide range of product applications.
- Product Qualities Unique specifications and Quality.
- Local manufactured company.

What is our brand Personality?

- Will be recognized as decorative long-life wood.

Specific in Target Market:

- Municipalities.
- Resorts and Clubs.
- Restaurants and Retails.
- Construction.

Target Market Approach:

- Will do a direct sale by sending a salesman to introduce company products and increase product awareness.

Market Challenges:

- Market limited awareness of the product.
- Competitors are well established in the market, whoever they are limited, just two competitors.

3.12. Target Marketing Strategy

- Mass marketing.

3.13. Target Segment Attractiveness

- Identifiable;
    i. Easy to collect project data.
    ii. Measurable in size and purchase power. (customer financial status)
- Profitable.
- Accessible, reachable.
- Responsive to the product.
- Fit the company's goals and strategy.

3.14. Positioning and Value Proposition

3.14.1. Customer Objectives

- Benches, Pergola, Decking, Cladding material, Windows, Doors, and Decorative material.
- Customers are looking for material with reliable quality.
- Customers need suppliers with a convenience store, and with a fast response in time.
- Customers need reasonable quality and price.

3.14.2. Value Propositioning Map

This section will draw company position among another competitor subject to response and quality as both are the most common concern among the customers. Using the value proposition map **Figure-24**, we can realize where is the company position is targeting and the possible future improvement needs it could be required.

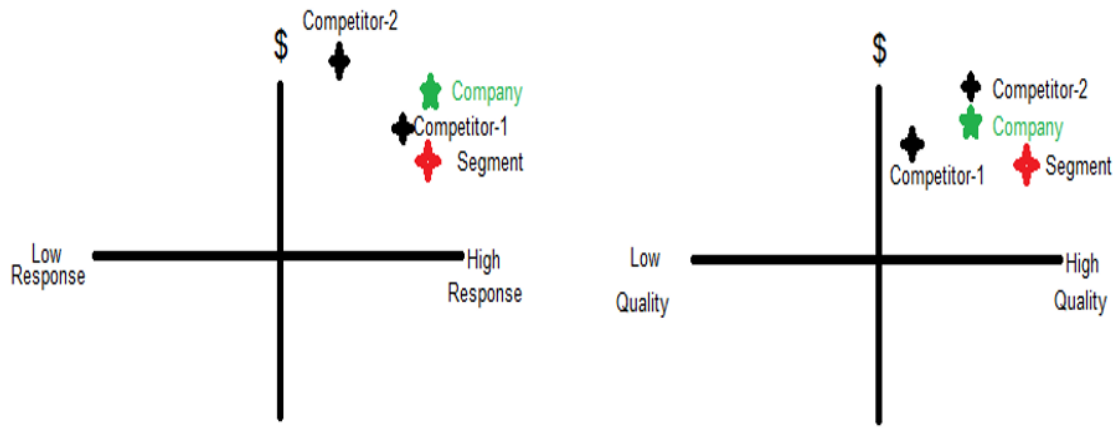


Figure-24 Company location on the value proposition map among the competitors

What Company can offer?

1) **Product design:**

- A variety of product applications and colors.
- A high quality and reliable product with a long-term guarantee.
- Decorative long-life wood.

3.15. Pricing Company Product Strategy

- Will be at a high price and profitable. Supported by fast response delivery date, convenience available stores, and long-term guarantee for a high-quality product.

3.16. Distribution Network

- Will build a strong logistic distribution network, with a competitive advantage for B2B suppliers.

3.17. Communication

- Will set a company website, and official company e-mail.
- Will hire a competent candidate for direct sales.
- Will give high priority to share in the construction exhibition.
- Will work in building a strong brand name with an attractive logo.

3.18. Company in Position Matrix

The company will target in the initial stage to give the high-quality product at a high price **Figure-25**. That in order to skim the market and to build their brand name. And in another stage of the product life cycle subject to market competency will offer two levels of product quality it could be with the different brand name; one will be high quality and the second one with a reasonable quality to compete with the market price if so. Accordingly, in the future company, it could have a different position with a separate brand name.

		Distriution wide		Distribution Exclusive	
		Low Quality	High Quality	Low Quality	High Quality
Promotion Heavy	Low Price				
	High Price				
Promotion Light	Low Price				
	High Price				Company Position

Figure-25 Company location on the position matrix

3.19. Company Strategy to Lead the Market

- Company strategy will target **Operational Excellence**. The company will work on giving a good production, delivery, price, and convenience.

Inconclusion (position statement):

- The company target commercial and public use application. Such as a construction projects company, resorts, clubs, municipalities, retails and restaurants.
- Company competitive advantage will be clearly presented in a variety of product applications, fast delivery, and responses.
- The product categories are: Benches, Pergola, Decking, Cladding material, fence, light pullets, Windows, Doors, and Decorative material for drums and planting pots.

3.20. Value Proposition

Company will serve the construction projects or any business, whose are looking for decorative long-life wood's material and a verity of its application to purchase from one account. And expected to have a reliable material and fast delivery, to satisfy their project needs for quality and progress.

Reasoning: The available suppliers are not capable to provide the variety of the product in an acceptable response time. Even some customer does not know about the product itself.

3.21. Marketing Strategies – (Product)

Wooden-Plastic is an environmentally friendly product, **Figure-26** It is characterized by unique properties that combine the good look of natural wood and durability, with the excellent characteristics of plastic that are resistant to water, moisture, and chemicals. Plastic-wood is also a clean product resistant to insects and fungi.

The value that this product will add to the consumer is that it is a lower maintenance cost. It is easy to install, and easy to dismantle, if the consumer wants to move to another place. Wooden-Plastic is a long-life product.

Wooden-Plastic products will be available in different grades. High grade (the percentage of recycled materials is

Figure-26

less), and it will be for outdoor use, and it will be better withstanding for weather conditions. Low grade (the proportion of recycled materials is high), and it will be for indoor use, where it has fewer weather conditions impact. That to control the price of the product, and to apply the value engineer.

The product will also offer another classification based on the additive materials that make it fire resistant with a different grade, upon request (One, Two, or Four hours fire-rated). That to suit the variety of applications and specifications of project requirements.

Another classification will offer different colors, and patterns, to suit different customer tastes, **Figure-27** More variety of applications for the product will be available. (Door, window, boxes, garden chairs, and cladding). Installation service will be provided at a later stage by the company.

Figure-27

3.22. Marketing Strategies – (Price)

Wooden-Plastic lifetime is twice lasting more than the natural wood, **Figure-28** [37]. Also, the cost of maintenance for Wooden-Plastic is almost zero. While, the Production cost of the Wooden-Plastic is less than natural wood, as it mainly depends on recycled materials.

We will adopt three points for pricing Wooden-Plastic:

1- Lower point price, based on the break-even point of the product (Price $ = (Fixed Cost, $ /Estimated expected sales, Units) +Variable Cost, $). That will be the bottom price we can reach, and must not break it by any way.

2- Midpoint price, which is the price of natural wood or the competitors' price. (if any for the same product).

3- Higher point price, which is estimated equal to two and a half times the price of natural wood. (Double cost since the life of the Wooden-Plastic is twice the long life of the natural wood & half is due to the value of the fewer maintenance costs and value of the time that could require for maintenance if we use a natural wood).

Figure-28

Based on the estimated value of the middle and upper points, will set the price of the product. The price will set between these two points and will consider the elasticity of the product price and demand.

Back to Egypt Market: the estimated average market of Natural wood is 400,000 m^3/ month Market [31], **Figure-29**. So, if we estimated initially Wooden-Plastic market is 10%, we estimate Wooden-Plastic equal to 4,000 m3/month.

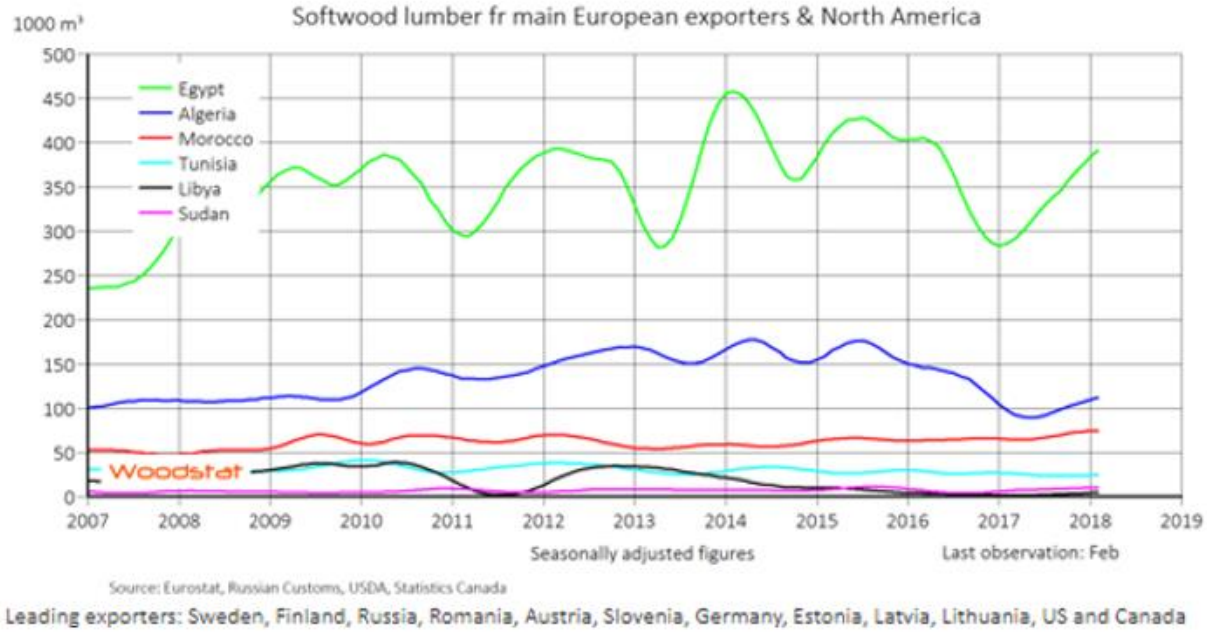


Figure-29

3.22.1. Calculation

1- Lower point price, based on the break-even point of the product (Price $ = (Fixed Cost, $ /Estimated expected sales, Units) +Variable Cost, $). Where is estimated expected sales = 4,000 m3/month, and others parameter will be calculated later upon operation stage.

2- Midpoint price, which is the price of natural wood, **Figure-30** [38] = 8,300 EGP/m^3.

3- Higher point price, which is estimated equal to two and a half times the price of natural wood = 2.5*8,300 = 20,750 EGP/m^3.

Finally, Competitors' prices will be considered, while adjusting the product price between the midpoint and higher point.

Figure-30

3.23. Marketing Strategies – (Place)

In the previous assignment, we determined our target segment, which was:

- **Municipalities.**
- **Resorts and Clubs.**
- **Decorative companies**.
- **Restaurants and Retails.**

As shown in **Figure-31** [31], there is a population density in the north of Egypt. Also, most of the construction and development work almost are concentrated in the north of Egypt. That, because of its competitive advantage of high population density. Thus, our strategy will focus primarily on distribution activity in the north of Egypt.

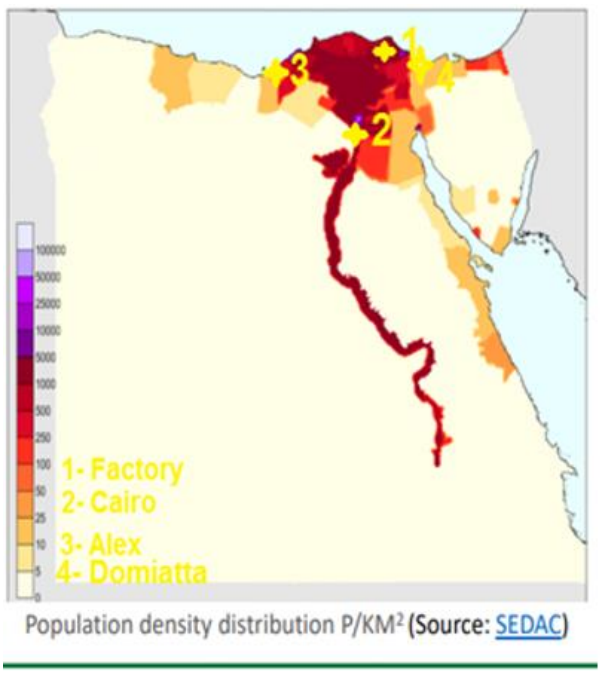


Figure-31

The Wooden-Plastic factory in our plan to establish in Gamasa industrial zone, which located on the international coastal road. That road is linking east and west of Egypt. This location is in the middle place between the suppliers of raw materials and distribution points. Recycled wood is from Damietta City, and recycled plastic its port. The main distribution is in Cairo city (The capital of Egypt) and Alexandria (the second-largest city in Egypt). Accordingly, we can ensure an efficient supply chain, which can reduce distribution costs.

We will adopt two distribution points for the product:

1- An inventory of the Cairo city, to serve the center and south of Egypt. Cairo is the big market in Egypt, where 10% of Egypt's population (100 million) [39]. It will be recommended in the future to open more than one distribution during the growth stage of the product life cycle. Cairo is about 3,085 km². This store will also serve the Red Sea coastal area, which has a lot of tourist villages along its coast (Hurghada, El Gouna, Sahl Hasheesh, Ain Sokhna, and Ras Sidr).
2- An inventory of the Alexandria city, to serve the northwest of Egypt. That will cover Alexandria city and the north coast because there are tourist villages along the coastal strip (North Egypt).
3- Finally, the factory will cover the Delta area directly. Delta area has a high population density that provides a large market. The factory also will serve the new cities on the coast adjacent to the factory (The New Mansoura city, May 15, and its environs).

3.24. Marketing Strategies – (Promotion)

Subject to our situated position in the position section will be light promotion. The company will not use the TV or Radio and will depend on direct sales and exhibition, plus the cheap media which is the online network.

Since the target group is mainly the commercial sector, such as municipalities, construction companies, decoration companies, retails, and restaurants. Hence it is the sector that can be approached directly by the salesperson. The company will send its sales representatives directly to the consumer. That approach will give a chance to emphasize the product's features, quality, and value. It will also allow us to know the consumer's opinions and needs better. This method is less expensive than TV ads.

Another way to promote our brand is by attending construction exhibits like Big-5 and décor exhibits. That will enable us to spread rapidly and may aid to open external markets that extend to other countries. Most exhibitions visitors are usually open mind and more receptive to modern technology and products.

The company will create product needs by promoting to stakeholders. The end-users such as the real estate developers, the owners, the consulting, design consultant. We will make sure to include our brand in the vendor list with consultants. We will distribute product samples, calendars, USBs, and notebooks have the brand name.

Online promotion, on the other hand, we will promote to the end-user through the company's official website for communication, Instagram for a bright photo showing the product application, and decorative work. Also, a Facebook page to show our previous and current projects. That will give a better image for the brand and will build trust. We may move to advertise on the Alibaba site at a later stage.

We have chosen the commercial sector, such as restaurants, tourist villages, clubs, and gardens because it's for public users. Thus, it becomes the largest practical promoter of our product. Our message will be **Company will serve the construction projects or any business, whose are looking for decorative long-life wood's material and a verity of its application to purchase from one account. And expected to have reliable material and fast delivery, to satisfy their project needs for quality and progress.**

3.25. Conclusion and Remarks

In light of the above mentioned, it is clear that we have a good product with desired specifications over the market. This product will provide a high value to the consumer. In return, we will be able to achieve a high benefit income. So, Wooden-Plastic is an attractive opportunity to invest. This product has achieved good sales in the countries where it has been before. After implemented the market research, it shows the limited competitors in the market (only two).

Wooden-Plastic will replace another product. And with higher specifications that exceed the current product, which is natural wood. Therefore, this product could be a reference to determine the price of the Wooden-Plastic. Also, there are only two suppliers on the market, which can be considered by a marketer, while setting the price.

For the distribution point, Egypt's demographic and population distribution are limited by limited area, which can be easy to cover somewhat from one distribution point. But because of brand position strategy to fast respond to the customer's need. Two additional distribution points are set by the company to deliver the product faster and to be more convenient to the consumer.

So, we adopted a light promotional, based on direct marketing and exhibitions, in addition to promoting online through social media and company websites.

Appendix-4- Technical Study

4.1. Product Formula

The used formula will have approximately;

$$Final\ Product = (52\%\ Wood\ Fiber) + (33\%\ PE) + (5\%\ ASA) + (10\%\ Additives)$$

- 5 % ASA for outer layer >> ASA resin has excellent mechanical properties, good thermal stability and significant weather resistance. Compared with ABS, ASA resin has better chemical resistance and environmental stress cracking resistance.
- 10 % additive and it will contain:
  - 3.2% Lubricant, it could be **Zinc Stearate** >> lubricant can facilitate the processing by reducing viscosity and maintaining the mechanical properties and surface smoothness. It has better strength due to the microplastic deformation of the resin. It also has better weather resistance.
  - 0.8% Foaming Agent, it could be **Azodicarbonamide AC** >> foaming agent it has favorable properties like reduced weight and cost, increased impact strength, strength-to-weight ratio, and surface definition (sharper contours and corners).
  - 3.8% Coupling agent, it could be **HMA Maleic anhydride** >> it uses to enhance blending homogenization, environmental improving, improve processability, dispersity, and consistency. Coupling agent generally consists of two parts: part is inorganic groups, can with the inorganic filler or reinforcement effect; The other part is organic affinity groups, but with synthetic resin.
  - 0.3% UV stabilizer, it could be **Hindered Amine Light Stabilizers >>** it used to enhance the durability reduce discolor and lose mechanical strength.
  - 0.4% Fire Retardant & Fungus Resistant, it could be **Zinc Borate** >> it used to reduce the weight loss of the wood component. Also, to add fire resistant to the product.
  - 1.5% Pigment, it could be Iron Oxide Red >> it is used to color the product.

Material name	Weight
Recycled PE flakes	33kgs (33 %)
Wood powder(80-100mesh)	52kgs (52 %)
ASA- Acrylate Styrene Acrylonitrile	5 Kgs (5 %)
Lubricant: Zinc Stearate	3.2kgs (3-5 %)
Foaming agent: Azodicarbonamide AC	0.8kgs (0.8-1.0%)
Coupling agent: HMA Maleic Anhydride	3.8kgs (3.8%-4%)
UV stabilizer: Hindered Amine Light Stabilizers	0.3 kgs (0.1%-0.5%)
Fire Retardant & Fungus Resistant: Zinc Borate	0.4kgs (0.1% -0.7%)

Note:

- The Wood to Plastic is subject to required application.
- The range of the additives percentage is subject to raw material supplier recommendations available on, https://www.maijisen-chem.com and https://www.alibaba.com

4.2. WPC, Material Flow Chart

Figure-32 shows the flow of the raw material until forming the final product.

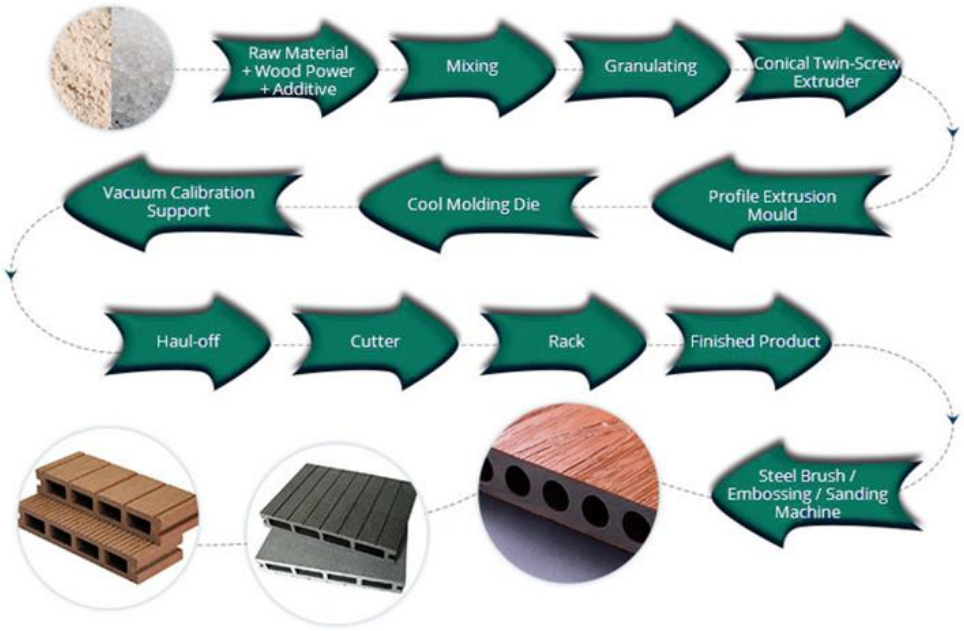


Figure-32

4.3. Required Product Test Certificates

In the below mention table list of the available tests related to WPC products.

Test	Standard
Tensile test	DIN EN ISO 527-2:2012-06
Bending Test	DIN EN ISO 178:2011-04
Charpy impact test	DIN EN ISO 179-1/1eA:2012-04
HDT-Heat Distortion Temperature	DIN EN ISO 75-2:2004-09
Linear Coefficient of Thermal Expansion (LCTE)	BS 3262-1: 1989 AMD 8783: 1995: APP. G
Weathering resistance e.g. 1000 h gray-scale	DIN EN ISO 4892-2:2013-06 method A/ ASTM D570-98 (R2010) e1
Color fastness and aging e.g. 1000 h gray-scale	BS 3262-1: 1989 AMD 8783: 1995: APP. C & D

4.4. Product Profile

4.4.1. For Cladding

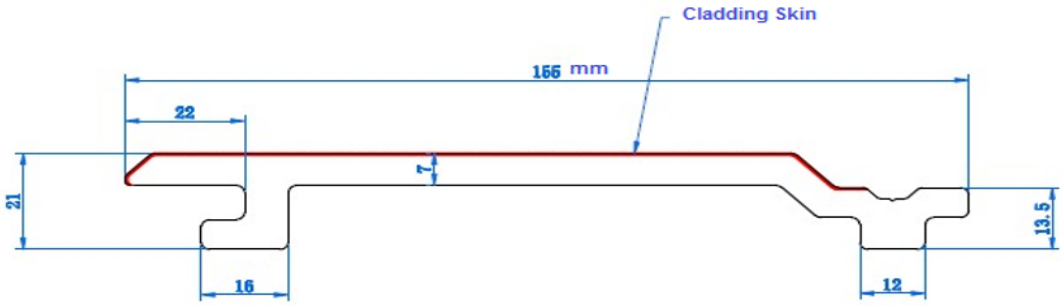


Figure-33

Figure-33 shows the most common use profile in the market and it was recommended by the machinery manufacture. The cladding skin it will manufacture from ASA and will have the pigment and UV resistance additives, that will provide the product with weather resistance and will reduce the product cost since the most expensive additives will reduce as it will dedicated in the thin layers. The corner and U shape included in this profile will enhance the product strengthen.

4.4.2. Other Types of Cladding Could be Used

Figure-34 shows other profiles it could be used for cladding work.

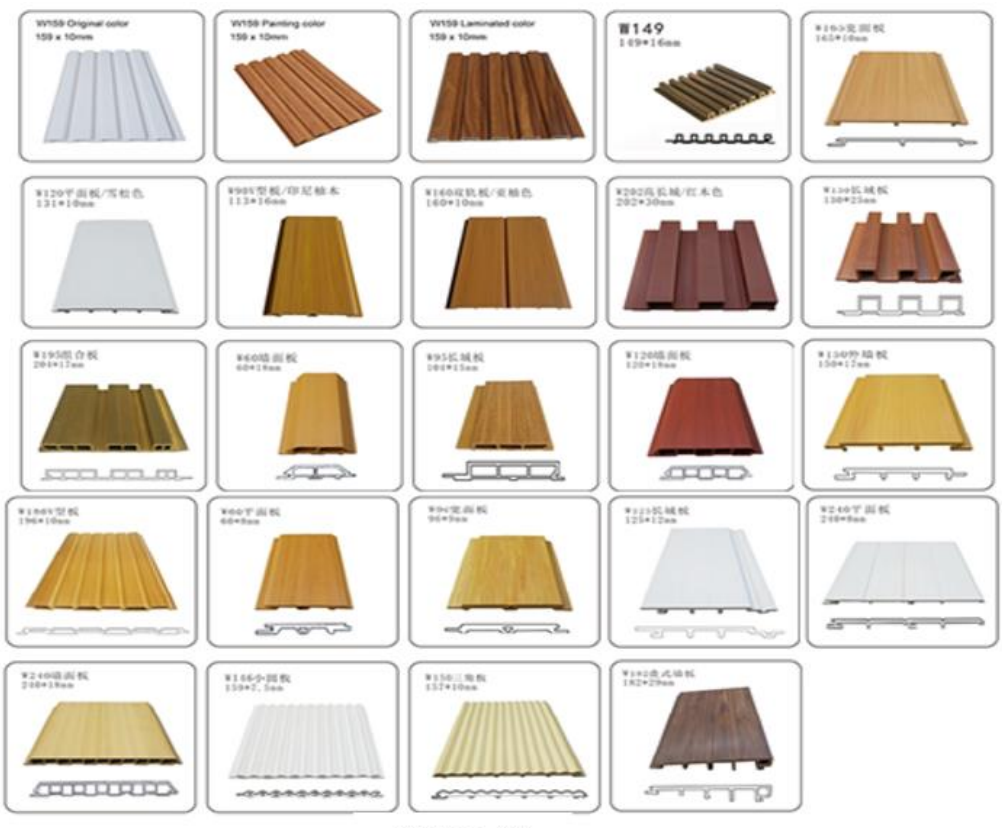


Figure-34

4.4.3. For Floor

Figure-35 shows the most common use profile in the market and it was recommended by the machinery manufacture. The cladding skin it will manufacture from ASA and will have the pigment and UV resistance additives, that will provide the product with weather resistance and will reduce the product cost since the most expensive additives will reduce as it will dedicated in the thin layers. The holes in the profile will reduce the raw material usage and will lead to reduce the cost and product weight as well.

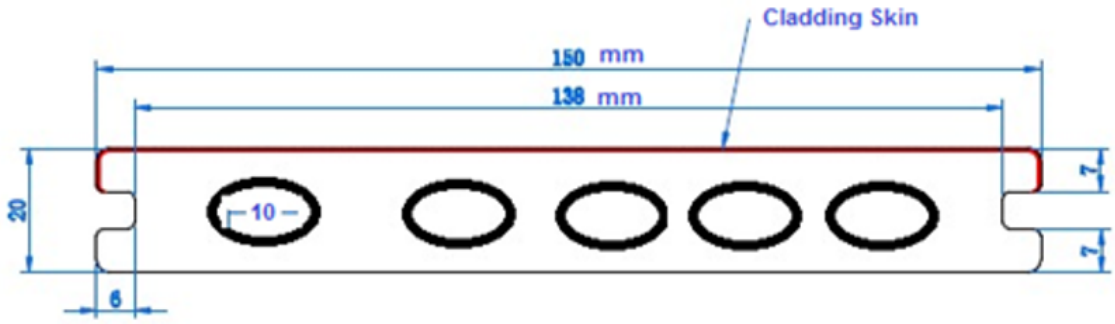


Figure-35

4.5. Engraving Works

4.5.1. Embossing

Embossing will provide the product with the natural look and feeling of wood.

Figure-36 shows non co-extruder profile online embossing machine comes with heating function.

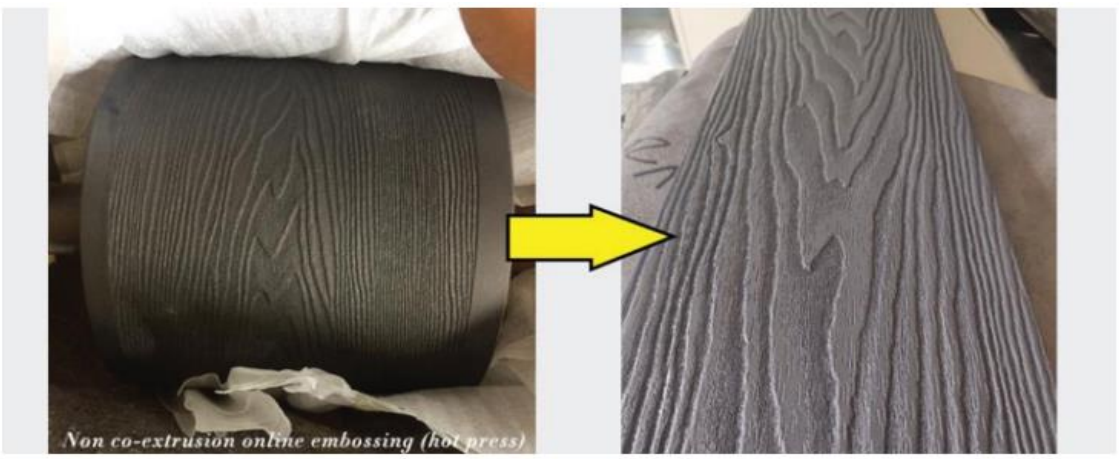


Figure-36

Figure-37 shows Co-extruder profile online embossing machine comes without heat function.

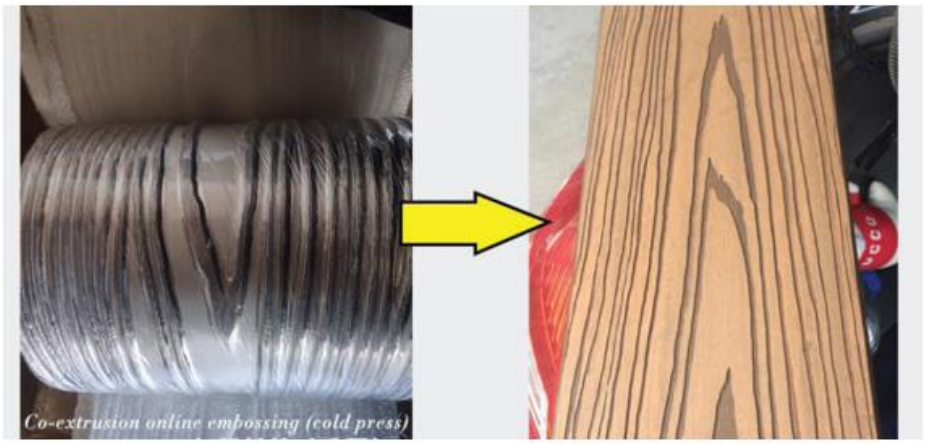


Figure-37

Steel Brush Machine

Application: make the WPC profile surface roughen like wood **Figure-38**. And it makes the product unslipping and it will serve the safety requirement.

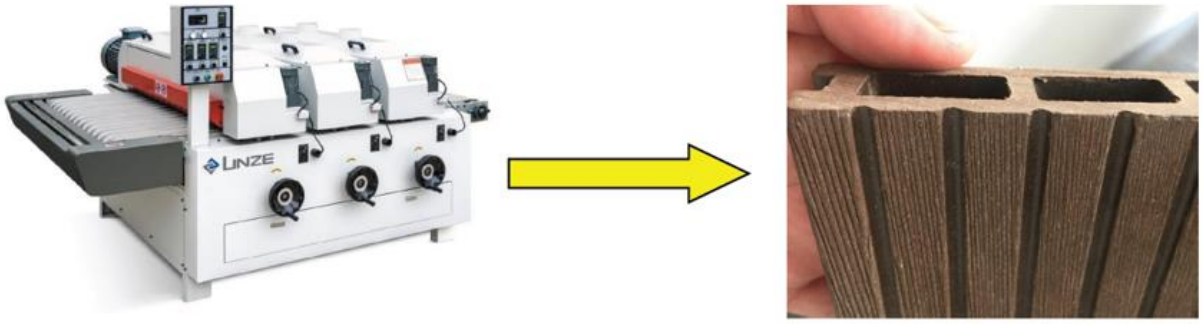


Figure-38

Sanding Machine

Application: make filament on the WPC decking to make it similar as wood **Figure-39**. And it makes the product unslipping and it will serve the safety requirement.

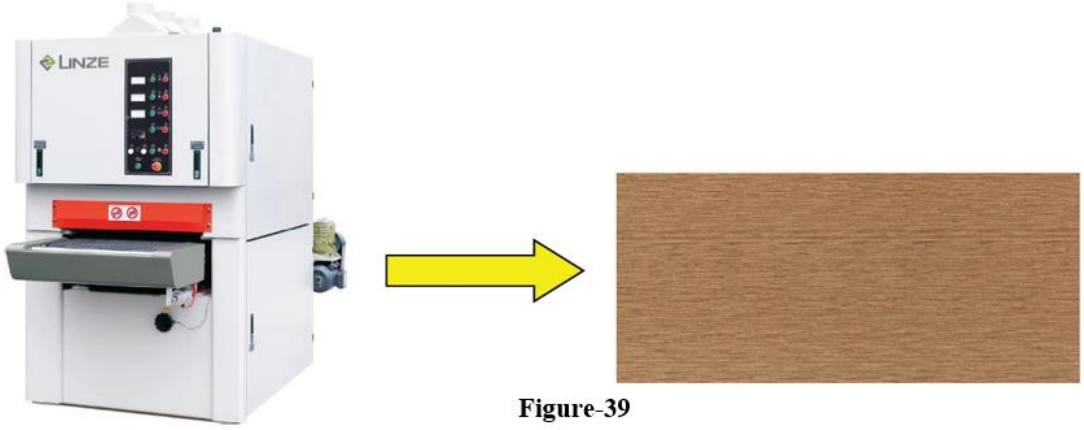


Figure-39

4.6. Final Product

Figure-40 shows the final product for cladding and floor.

Figure-40

4.7. Factory Line Specifications

4.7.1. Main Line Technical Specification

Phase	Unit	Average
Production Line Capacity	Kg/hr.	250
Monthly Production Rate, [1 shift, 10hr]	Ton/Month	60
Total Power Consumption	KW.hr	512
Workshop Area	M2	680

4.8. WPC, Process Flow Chart

Figure-41 shows WPC the process flow.

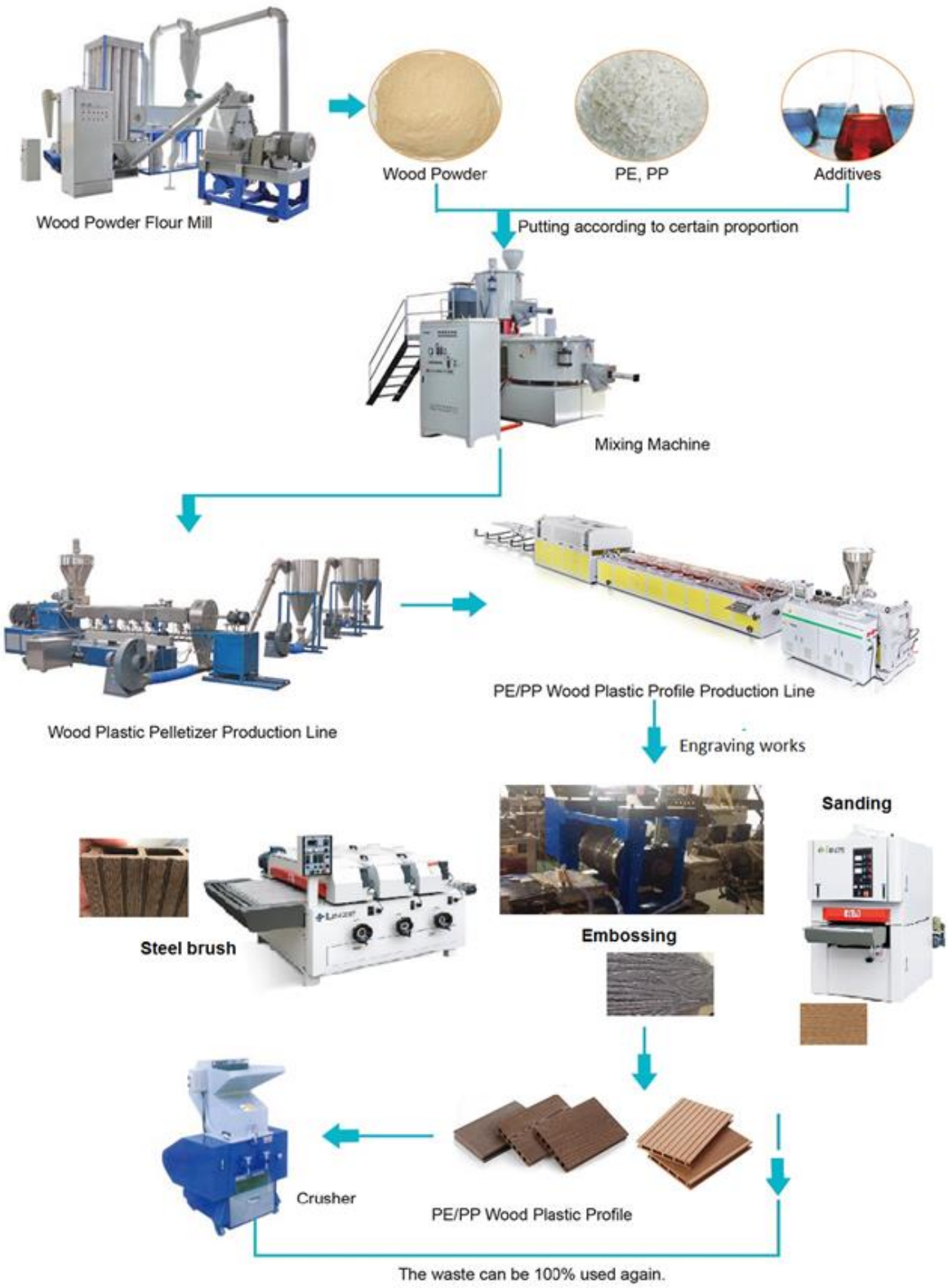
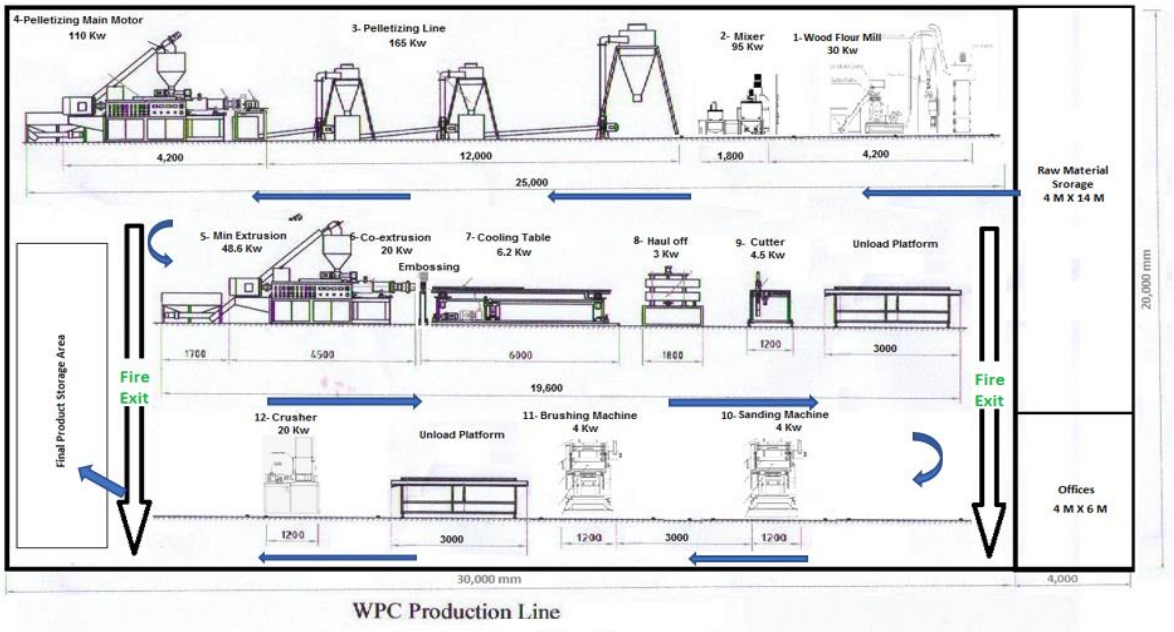


Figure-40

4.9. Factory Layout

The proposed layout is based on Lean Six Sigma recommended production line is to be in U-shape **Figure-41** process distribution, that to reduce movement waste, which will consider in distributing the production machine locations as mentioned in the below factory layout:

- Factory Workshop Are = 20 m X 30 m
- Raw Material Storage Area = 4 m X 14 m
- Office Area = 4 m X 6 m



WPC Production Line

Figure-41

4.10. Electricity Consumption

No.	Machine	Electricity consumption
01	Wood Flour Mill	30 kw
02	Mixer	96 kw
03	Pelletizing Line	165 kw
04	Pelletizing Main Motor	110 kw
05	WPC Profile Extruder	49 kw
06	Co-extrusion	20 kw
07	Cooling Table	6.2 kw
08	Haul off	3 kw
09	Cutter	4.5 kw
10	Sanding Machine	4 kw
11	Brushing Machine	4 kw
12	Crusher	20 kw
Total Power		511.7 Kw

Electric power supply: 3phase

4.11. Concerns During Factory Setup. (Construction Stage)

4.11.1. Stakeholder Management Responsibilities

Stakeholder Analysis							
ID	Stakeholder	Role	Impact (Interest)	Influence (Power)	Risk Tolerance	Needs	Responsibility
01	Environmental Authority	Accept the use of raw material and recycling process of the factory outputs.	High	High	High	Actively Engagement	Project Manager
02	Egyptian Customs Authority	Accept the imported material & assigned the customs fees for the imported material.	Low	High	High	Keep Satisfied	Project Manager
03	Egyptian Tax Authority	Open Tax file & Assigned the Tax fee on the revenue/income.	Low	High	High	Keep Satisfied	Project Manager
04	The National Authority of Social Insurance (Labor Authority)	Register employees.	Low	High	Medium	Keep Satisfied	Project Manager
05	Civil Defense	Accept the fire fighting plane, FF system and alarm system.	High	High	High	Actively Engagement	Project Manager
06	Ministry of Petroleum	Approve the natural gas consumption rate.	Low	High	Low	Keep Satisfied	Project Manager
07	Industrial area properties	managing the industrial area / rent the factory land.	Low	High	Low	Keep Satisfied	Project Manager
08	Raw material providers	Supply/Selling raw material.	High	High	High	Actively Engagement	Sales Manager
09	Distributors/Customer	Buying the final products.	High	High	High	Actively Engagement	Sales Manager
10	Competitors (Wooden-plastic suppliers)	Importing companies for wooding-plastic products from out of country.	High	High	High	Actively Watching	Sales Manager
11	Competitors (Wooden-plastic substitutes).	The suppliers for alternative products like i.e.; natural woods, HDF, Plastic companies etc.	High	High	High	Actively Watching	Sales Manager
12	Test Laboratories	Release product test certificate	Low	High	Medium	Keep Satisfied	Sales Manager
13	Chamber of commerce	Obtain Chamber of Commerce Certificate.	Medium	Low Medium	Low	Monitor	Project Manager
14	Ministry of industries	Company register & business approval.	Medium	Low Medium	Low	Keep Satisfied	Project Manager
15	Water & Electrical Authority	Approve the water and electrical consumption rate.	Medium High	Medium High	Low	Actively Engagement	Project Manager

4.11.2. Factory Scope of Work Responsibilities

RESPONSIBILITY
ASSIGNMENT MATRIX

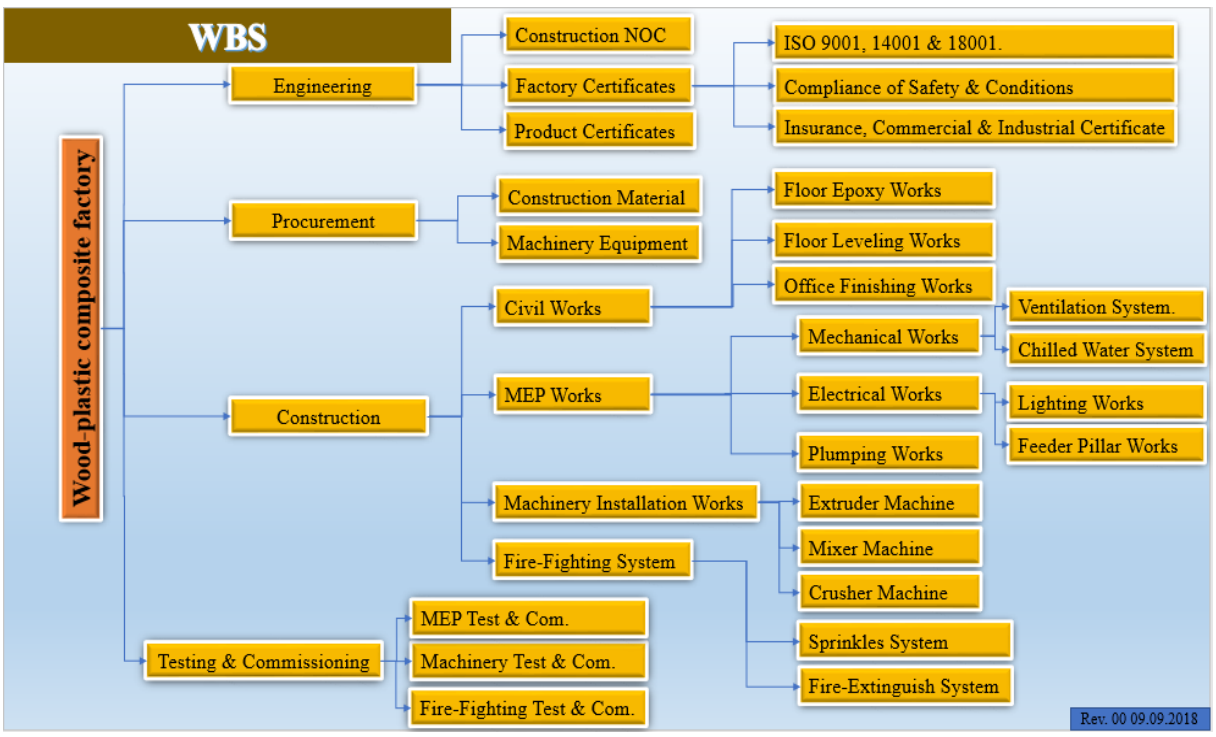
Stage	SOW, (Scope of work)	Operation Manager (Acting Project Manager)	Senior Sales Engineer	Fire-Fighting Sub-contractor	MEP Sub-contractor	Civil Sub-contractor	Machinery Supplier
Construction	Factory NOC/Work Permit	R		S	S	S	N
	Fire-fighting work	A		R		S	
	Mechanical work	A			R	S	A
	Plumping work	A			R	N	N
	Electrical work	A			R		A
	Civil work	A				R	N
	Machinery Installation	A	N		S		R
Certificates	Factory License/Certificate	R	R				
	Product Certificate	S	R				S

A- Approved ..... S- Support ..... R- Responsible ..... N-Notification

4.11.3. Project Meetings and Reports

Project Meetings & Reports											
Meeting Description	Frequency	Location	Chair	Minutes	Attendees						
					Owner /Client	Operation Manager	Senior Sales Engineer	Fire-Fighting Sub-contractor	MEP Sub-contractor	Civil Sub-contractor	Machinery Supplier
Project Meeting (Project Presentation)	Monthly	Site Office	Operation Manager	Document Controller	*	*	*		*	*	*
Project Progress Meeting	Bi-Weekly	Site Office	Operation Manager	Document Controller		*	*		*	*	*
Design Meeting	As Required	Site Office	Operation Manager	Document Controller		*		*	*	*	*
Project Technical Meeting	As Required	Site Office	Operation Manager	Document Controller		*		*	*	*	*
Project Coordination Meeting	As Required	Site Office	Operation Manager	Document Controller		*		*	*	*	*

4.11.4. WBS of Factory during Setup Stage

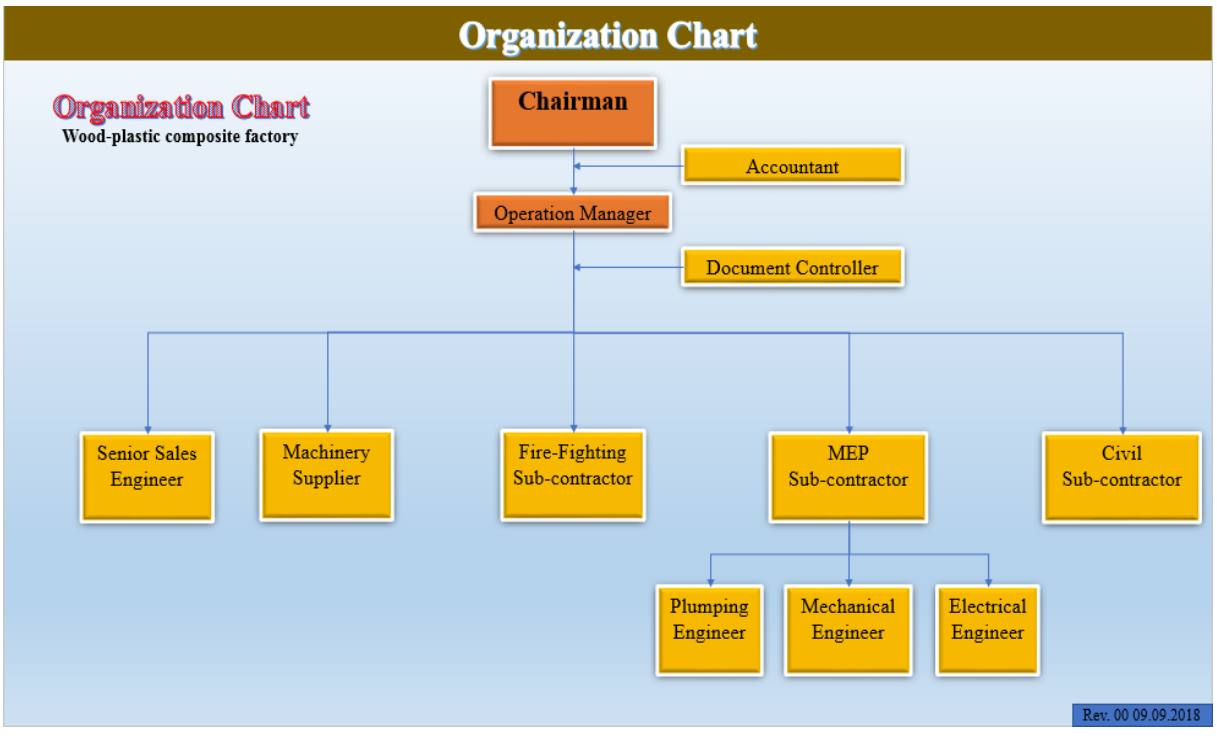


4.11.5. Project Schedule Baseline

Project Schedule Baseline

Activity	Duration [Week]	Month: 1M	2M	3M	4M	5M	6M	7M	8M	9M
		Week: 01 02 03 04	05 06 07 08	09 10 11 12	13 14 15 16	17 18 19 20	21 22 23 24	25 26 27 28	29 30 31 32	33 34 35 36
Mobilization	4	■								
Engineering	12		■	■	■	■				
Procurement	8				■	■				
Civil Works	8						■	■		
MEP Works	8						■	■	■	
Fire-Fighting	2								■	
Installing Machinery	2								■	
T&C	1									■
Epoxy Floor	1									■
ISO Certificate	3									■
Product Certificate	3									■
Handing Over	1									■

4.12. Concerns during Factory Running. (Production Stage)



Appendix-5- Finance Study

It takes approximately one month, and after long discussions and communication with the machinery and raw material supplier. During this interval, we gain a lot of technical information, which helped us to know more about the practical endeavor to produce WPC. It was penitential for discussion we take during the preparation of this project, especially for the market plan section.

5.1. Machinery Costs

After filtering the quotations, we have received during the collection quotation period, we became satisfied with six quotations from different suppliers which showed the most accurate data, especially ANDA Machinery Co. LTD and JIANGSU KING SHINE PLASTIC MACHINE CO., LTD both of them showed a professional way of communication. All suppliers promise 60 days to keep all required machinery ready to collect from china port. The payment term was 30/70 means 30 % on advice payment and 70 % after machinery inspection. This cost includes a one-year warranty. The below table shows the comparison sheet for the machinery supplier price.

Supplier Name:

1- ZHANGJIAGANG XINHE MACHINERY CO, LTD
2- QINGDAO HEGU WOOD PLASTIC MACHINERY CO., LTD
3- Zhangjiagang Seven stars Machinery CO, LTD
4- Zhangjiagang City Qingshang Plastic Machinery CO, LTD
5- ANDA Machinery CO., LTD
6- JIANGSU KINGSHINE PLASTIC MACHINE CO., LTD

Comparison Sheet									
Supplier Name	ZHANGJIAGANG XINHE MACHINERY CO,LTD	QINGDAO HEGU WOOD PLASTIC MACHINERY CO,.LTD	Zhangjiagang Sevenstars Machinery Co.,Ltd	Zhangjiagang City Qiangsheng Plastic Machinery Co., Ltd.	ANDA Machinery Co.LTD	JIANGSU KINGSHINE PLASTIC MACHINE CO., LTD	Comparison Phase		
Machine	Price , USD	Price , USD	Price , USD	Price , USD	Price , USD	Price , USD	Maximum	Minimum	Average
Mixer equipment:									
Mixer machine	14,800.00	10,000.00	13000	10900	16500	17200	17,200.00	10,000.00	13,733.33
Pelletizing Equipment:									
Parallel Co-rotating Twin Screw Air-cooling Die Face **Pelletizing** Line	65,625.00	58,000.00	52000		45000	70000	65,625.00	45,000.00	55,156.25
WPC profile estrusion line:									
PE Wood -plastic Floor **Production Line** + Co-estruder Machine	31,250.00	42,800.00	30000	34000	41500	47000	47,000.00	30,000.00	37,758.33
Mold, (For Decking Board)	4,687.00	5,500.00	4500	3500	3800		5,500.00	3,500.00	4,397.40
Mold, (For Cladding Profile)	4,375.00	5,300.00	4500	3500	3800		5,300.00	3,500.00	4,295.00
Surface treating machine:									
Grinding machine = SANDING MACHINE	7,500.00	9,500.00		9000	3300	9500	9,500.00	3,300.00	7,760.00
OFFLINE BURSHING MACHINE		9,500.00		7700	3000	9500	9,500.00	3,000.00	7,425.00
Embossing machine	8,750.00	10,000.00		8700	4000	4500	10,000.00	4,000.00	7,190.00
Recycling machine:									
Crush machine	4,375.00	2,000.00	5000	3000	3500	5500	5,500.00	2,000.00	3,895.83
WOOD CUTTING MACHINE		7,500.00					7,500.00	7,500.00	7,500.00
WOOD POWDER MILLER		25,000.00		3200	7500		25,000.00	3,200.00	11,900.00
WOOD POWDER DRYER		23,000.00			4500		23,000.00	4,500.00	13,750.00
Water Chiller (cooling water to get better quality)			15000		5000		15,000.00	5,000.00	10,000.00
Air Compressor			5500				5,500.00	5,500.00	5,500.00
	141,362	208,100	129,500	83,500	141,400	163,200	251,125	130,000	190,261
Delivery Time: (FOB China port)	60 Days	60 Days	60 Days	60 Days	60 Days	60 Days	60 Days	60 Days	60 Days
Payment Term: [Advance/Final]	30/70	30/70	30/70	30/70	30/70	30/70	30/70	30/70	30/70

5.2. Raw Material Costs

Our reference for raw material costs was Alibaba's website and other Egyptian unofficially communication. Based on maximum extruder capacity of 250 [Kg/hr.], and the one shift of day hours 10 [hr./ day shift], and working days in month 24 [Day/Month], the raw material cost was calculated. The costs result as mention in the below table:

Material name	Ave. Weight in WPC	Price [USD/Ton]	Plan Weight [%]	Monthly Usage [Kg]	Monthly Expenses [USD]
Recycled PE flakes	(33%)	445-535	33.00%	19,800	10,593
Wood powder(80-100mesh)	(52%)	20-30	52.00%	31,200	936
ASA- Acrylate Styrene Acrylonitrile	(5%)	1400	5.00%	3,000	5,400
Lubricant: Zinc Stearate	(3-5 %)	1300	3.20%	1,920	2,496
Foaming agent: Azodicarbonamide AC	(0.8-1.0%)	2200	0.80%	480	1,056
Coupling agent: HMA Maleic Anhydride	(3.8%-4%)	860	3.80%	2,280	1,960
UV stabilizer: Hindered Amine Light Stabilizers	(0.1%-0.5%)	5000	0.30%	180	900
Fire Retardant & Fungus Resistant: Zinc Borate	(0.1% -0.7%)	1600	0.40%	240	384
Pigment: Iron Oxide Red (Color agent)	(1.5%)	700	1.50%	900	630
			Total:	60,000 KG	24,355

So, at the total capacity of 60 Tons, raw material costs 24,355 USD per month per shift.

5.3. Product Test Certificate Costs

After market survey we found that its recommended test and laboratory cost as mentioned in below table:

Product Test Certificate		
Test	Standard	Price [USD]
Tensile test	DIN EN ISO 527-2:2012-06	45
Bending Test	DIN EN ISO 178:2011-04	27
Charpy impact test	DIN EN ISO 179-1/1eA:2012-04	17
HDT-Heat Distortion Temperature	DIN EN ISO 75-2:2004-09	13
Linear Coefficient of Thermal Expansion (LCTE)	BS 3262-1: 1989 AMD 8783: 1995: APP. G	9
Weathering resistance e.g. 1000 h gray-scale	DIN EN ISO 4892-2:2013-06 method A/ ASTM D570-98 (R2010) e1	19
Color fastness and aging e.g. 1000 h gray-scale	BS 3262-1: 1989 AMD 8783: 1995: APP. C & D	54
Total Cost [USD]		183

5.4. Employee Wedges

The expected monthly wedges are listed as in below mentioned table.

Profession	Monthly Rate [USD]
General Manager	1,274
Operation Engineer	575
Sales Man	510
Accountant	446
Secretary	159
Mechanical Technician	191
Electrical Technician	191
Foreman X 2	510
Helper X 5	478
Security	159

5.5. Other Expenses

The next table is listed the other expenses it may applied.

Type	Cost [USD]
Factory Sign Board	223
Floor Epoxy	3,185
Office Air Condition	860
Annual Rent of Factory	2,229
Monthly Office Electricity	32
Annual Factory Insurance	510
Monthly Advertise Expenses	64
Monthly Telephone & IT Expenses	41
Monthly Office Tea & Coffee	32
Monthly Factory Electricity (Machinery)	3,210
Monthly Transportation	637
Annual Exhibition (Will start from the second year)	3,185

5.6. Project Cash Flow

5.6.1. First Year Cash Flow

	Activity	1Y											
		Month											
		1	2	3	4	5	6	7	8	9	10	11	12
Fixed Cost	MEP Works	-	-	3,185	1,592	-	-	-	-	-	-	-	-
	Civil Works	-	-	1,592	1,592	-	-	-	-	-	-	-	-
	Epoxy Floor Coating	-	-	-	-	-	3,185	-	-	-	-	-	-
	Machinery + Transportation	133,500	-	-	-	-	-	-	-	-	-	-	-
	Product Certificate	-	-	-	-	-	183	-	-	-	-	-	-
	ISO Certificate	-	-	-	-	-	955	-	-	-	-	-	-
	Factory Office Furniture	-	-	-	1,592	-	-	-	-	-	-	-	-
	Factory License	4,777	-	-	-	-	-	-	-	-	-	-	-
	Offices Air Condition	-	-	-	860	-	-	-	-	-	-	-	-
Over Head Costs	General Manager	1,274	1,274	1,274	1,274	1,274	1,274	1,274	1,274	1,274	1,274	1,274	1,274
	Operation Engineer	-	-	573	573	573	573	573	573	573	573	573	573
	Sales Man	-	-	-	510	510	510	510	510	510	510	510	510
	Accountant	446	446	446	446	446	446	446	446	446	446	446	446
	Secretary	-	-	159	159	159	159	159	159	159	159	159	159
	Mechanical Technician	-	-	-	-	191	191	191	191	191	191	191	191
	Electrical Technician	-	-	-	-	191	191	191	191	191	191	191	191
	Foreman X 2	-	-	-	-	-	510	510	510	510	510	510	510
	Helper X 5	-	-	-	-	-	478	478	478	478	478	478	478
	Security	-	-	-	-	-	159	159	159	159	159	159	159
	Office Expenses, Coffee	32	32	32	32	32	32	32	32	32	32	32	32
	Telephone & IT Expenses	-	-	-	-	-	41	41	41	41	41	41	41
	Exhibition	-	-	-	-	-	-	-	-	-	-	-	-
	Advertising	64	64	64	64	64	64	64	64	64	64	64	64
	Factory Rent	2,229	2,229	2,229	2,229	2,229	2,229	2,229	2,229	2,229	2,229	2,229	2,229
	Factory Insurance	510	-	-	-	-	-	-	-	-	-	-	-
	Offices Electricity	32	32	32	32	32	32	32	32	32	32	32	32
Run Cost	Raw Material Consumption	-	-	-	-	-	-	12,178	12,178	12,178	12,178	12,178	12,178
	Factory Electricity Expenses	-	-	-	-	-	-	3,210	3,210	3,210	3,210	3,210	3,210
	Transportation	-	-	-	-	-	-	318	318	318	318	318	318
		-	-	-	-	-	-	-	-	-	-	-	-
		-	-	-	-	-	-	-	-	-	-	-	-
		-	-	-	-	-	-	-	-	-	-	-	-
	Total Expenses	142,863	4,076	9,586	10,935	5,701	11,211	22,594	22,594	22,594	22,594	22,594	22,594
	Sales Revenue	-	-	-	-	-	-	30,976	30,976	30,976	30,976	30,976	30,976
	Total Margin	(142,863)	(4,076)	(9,586)	(10,935)	(5,701)	(11,211)	8,382	8,382	8,382	8,382	8,382	8,382

5.6.2. Second Year Cash Flow

	Activity	2Y											
		13	14	15	16	17	18	19	20	21	22	23	24
Fixed Cost	MEP Works	-	-	-	-	-	-	-	-	-	-	-	-
	Civil Works	-	-	-	-	-	-	-	-	-	-	-	-
	Epoxy Floor Coating	-	-	-	-	-	-	-	-	-	-	-	-
	Machinery + Transportation	-	-	-	-	-	-	-	-	-	-	-	-
	Product Certificate	-	-	-	-	-	-	-	-	-	-	-	-
	ISO Certificate	-	-	-	-	-	-	-	-	-	-	-	-
	Factory Office Furniture	-	-	-	-	-	-	-	-	-	-	-	-
	Factory License	-	-	-	-	-	-	-	-	-	-	-	-
	Offices Air Condition	-	-	-	-	-	-	-	-	-	-	-	-
Over Head Costs	General Manager	1,274	1,274	1,274	1,274	1,274	1,274	1,274	1,274	1,274	1,274	1,274	1,274
	Operation Engineer	573	573	573	573	573	573	573	573	573	573	573	573
	Sales Man	510	510	510	510	510	510	510	510	510	510	510	510
	Accountant	446	446	446	446	446	446	446	446	446	446	446	446
	Secretary	159	159	159	159	159	159	159	159	159	159	159	159
	Mechanical Technician	191	191	191	191	191	191	191	191	191	191	191	191
	Electrical Technician	191	191	191	191	191	191	191	191	191	191	191	191
	Foreman X 2	510	510	510	510	510	510	510	510	510	510	510	510
	Helper X 5	478	478	478	478	478	478	478	478	478	478	478	478
	Security	159	159	159	159	159	159	159	159	159	159	159	159
	Office Expenses, Coffee	32	32	32	32	32	32	32	32	32	32	32	32
	Telephone & IT Expenses	41	41	41	41	41	41	41	41	41	41	41	41
	Exhibition	-	-	-	-	-	-	-	-	-	-	-	-
	Advertising	64	64	64	64	64	64	64	64	64	64	64	64
	Factory Rent	2,229	2,229	2,229	2,229	2,229	2,229	2,229	2,229	2,229	2,229	2,229	2,229
	Factory Insurance	510	-	-	-	-	-	-	-	-	-	-	-
	Offices Electricity	32	32	32	32	32	32	32	32	32	32	32	32
Run Cost	Raw Material Consumption	18,267	18,267	18,267	18,267	18,267	18,267	24,356	24,356	24,356	24,356	24,356	24,356
	Factory Electricity Expenses	3,210	3,210	3,210	3,210	3,210	3,210	3,210	3,210	3,210	3,210	3,210	3,210
	Transportation	425	425	425	425	425	425	637	637	637	637	637	637
		-	-	-	-	-	-	-	-	-	-	-	-
		-	-	-	-	-	-	-	-	-	-	-	-
		-	-	-	-	-	-	-	-	-	-	-	-
	Total Expenses	29,299	28,790	28,790	28,790	28,790	28,790	35,091	35,091	35,091	35,091	35,091	35,091
	Sales Revenue	46,464	46,464	46,464	46,464	46,464	46,464	61,953	61,953	61,953	61,953	61,953	61,953
	Total Margin	17,165	17,675	17,675	17,675	17,675	17,675	26,862	26,862	26,862	26,862	26,862	26,862

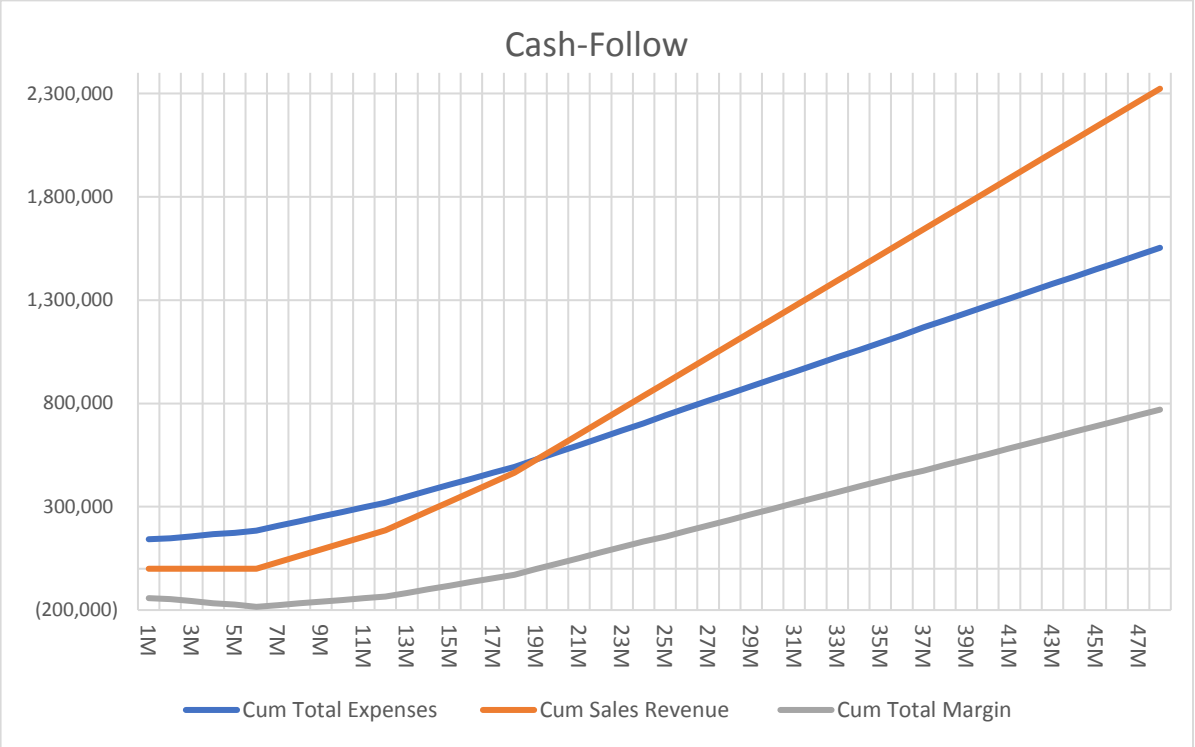
5.6.3. Third Year Cash Flow

	Activity	3Y											
		25	26	27	28	29	30	31	32	33	34	35	36
Fixed Cost	MEP Works	-	-	-	-	-	-	-	-	-	-	-	-
	Civil Works	-	-	-	-	-	-	-	-	-	-	-	-
	Epoxy Floor Coating	-	-	-	-	-	-	-	-	-	-	-	-
	Machinery+ Transportation	-	-	-	-	-	-	-	-	-	-	-	-
	Product Certificate	-	-	-	-	-	-	-	-	-	-	-	-
	ISO Certificate	-	-	-	-	-	-	-	-	-	-	-	-
	Factory Office Furniture	-	-	-	-	-	-	-	-	-	-	-	-
	Factory License	-	-	-	-	-	-	-	-	-	-	-	-
	Offices Air Condition	-	-	-	-	-	-	-	-	-	-	-	-
Over Head Costs	General Manager	1,274	1,274	1,274	1,274	1,274	1,274	1,274	1,274	1,274	1,274	1,274	1,274
	Operation Engineer	573	573	573	573	573	573	573	573	573	573	573	573
	Sales Man	510	510	510	510	510	510	510	510	510	510	510	510
	Accountant	446	446	446	446	446	446	446	446	446	446	446	446
	Secretary	159	159	159	159	159	159	159	159	159	159	159	159
	Mechanical Technician	191	191	191	191	191	191	191	191	191	191	191	191
	Electrical Technician	191	191	191	191	191	191	191	191	191	191	191	191
	Foreman X 2	510	510	510	510	510	510	510	510	510	510	510	510
	Helper X 5	478	478	478	478	478	478	478	478	478	478	478	478
	Security	159	159	159	159	159	159	159	159	159	159	159	159
	Office Expenses, Coffee	32	32	32	32	32	32	32	32	32	32	32	32
	Telephone & IT Expenses	41	41	41	41	41	41	41	41	41	41	41	41
	Exhibition	3,185	-	-	-	-	-	-	-	-	-	-	-
	Advertising	64	64	64	64	64	64	64	64	64	64	64	64
	Factory Rent	2,229	2,229	2,229	2,229	2,229	2,229	2,229	2,229	2,229	2,229	2,229	2,229
	Factory Insurance	510	-	-	-	-	-	-	-	-	-	-	-
	Offices Electricity	32	32	32	32	32	32	32	32	32	32	32	32
Run Cost	Raw Material Consumption	24,356	24,356	24,356	24,356	24,356	24,356	24,356	24,356	24,356	24,356	24,356	24,356
	Factory Electricity Expenses	3,210	3,210	3,210	3,210	3,210	3,210	3,210	3,210	3,210	3,210	3,210	3,210
	Transportation	637	637	637	637	637	637	637	637	637	637	637	637
		-	-	-	-	-	-	-	-	-	-	-	-
		-	-	-	-	-	-	-	-	-	-	-	-
		-	-	-	-	-	-	-	-	-	-	-	-
	Total Expenses	38,785	35,091	35,091	35,091	35,091	35,091	35,091	35,091	35,091	35,091	35,091	35,091
	Sales Revenue	61,953	61,953	61,953	61,953	61,953	61,953	61,953	61,953	61,953	61,953	61,953	61,953
	Total Margin	23,168	26,862	26,862	26,862	26,862	26,862	26,862	26,862	26,862	26,862	26,862	26,862

5.6.4. Fourth Year Cash Flow

	Activity	4Y											
		37	38	39	40	41	42	43	44	45	46	47	48
Fixed Cost	MEP Works	0	0	0	0	0	0	0	0	0	0	0	0
	Civil Works	0	0	0	0	0	0	0	0	0	0	0	0
	Epoxy Floor Coating	0	0	0	0	0	0	0	0	0	0	0	0
	Machinery+ Transportation	0	0	0	0	0	0	0	0	0	0	0	0
	Product Certificate	0	0	0	0	0	0	0	0	0	0	0	0
	ISO Certificate	0	0	0	0	0	0	0	0	0	0	0	0
	Factory Office Furniture	0	0	0	0	0	0	0	0	0	0	0	0
	Factory License	0	0	0	0	0	0	0	0	0	0	0	0
	Offices Air Condition	0	0	0	0	0	0	0	0	0	0	0	0
Over Head Costs	General Manager	1,274	1,274	1,274	1,274	1,274	1,274	1,274	1,274	1,274	1,274	1,274	1,274
	Operation Engineer	573	573	573	573	573	573	573	573	573	573	573	573
	Sales Man	510	510	510	510	510	510	510	510	510	510	510	510
	Accountant	446	446	446	446	446	446	446	446	446	446	446	446
	Secretary	159	159	159	159	159	159	159	159	159	159	159	159
	Mechanical Technician	191	191	191	191	191	191	191	191	191	191	191	191
	Electrical Technician	191	191	191	191	191	191	191	191	191	191	191	191
	Foreman X 2	510	510	510	510	510	510	510	510	510	510	510	510
	Helper X 5	478	478	478	478	478	478	478	478	478	478	478	478
	Security	159	159	159	159	159	159	159	159	159	159	159	159
	Office Expenses, Coffee	32	32	32	32	32	32	32	32	32	32	32	32
	Telephone & IT Expenses	41	41	41	41	41	41	41	41	41	41	41	41
	Exhibition	3,185	-	-	-	-	-	-	-	-	-	-	-
	Advertising	64	64	64	64	64	64	64	64	64	64	64	64
	Factory Rent	2,229	2,229	2,229	2,229	2,229	2,229	2,229	2,229	2,229	2,229	2,229	2,229
	Factory Insurance	510	-	-	-	-	-	-	-	-	-	-	-
	Offices Electricity	32	32	32	32	32	32	32	32	32	32	32	32
Run Cost	Raw Material Consumption	24,356	24,356	24,356	24,356	24,356	24,356	24,356	24,356	24,356	24,356	24,356	24,356
	Factory Electricity Expenses	3,210	3,210	3,210	3,210	3,210	3,210	3,210	3,210	3,210	3,210	3,210	3,210
	Transportation	637	637	637	637	637	637	637	637	637	637	637	637
		0	0	0	0	0	0	0	0	0	0	0	0
		0	0	0	0	0	0	0	0	0	0	0	0
		0	0	0	0	0	0	0	0	0	0	0	0
	Total Expenses	38,785	35,091	35,091	35,091	35,091	35,091	35,091	35,091	35,091	35,091	35,091	35,091
	Sales Revenue	61,953	61,953	61,953	61,953	61,953	61,953	61,953	61,953	61,953	61,953	61,953	61,953
	Total Margin	23,168	26,862	26,862	26,862	26,862	26,862	26,862	26,862	26,862	26,862	26,862	26,862

5.6.5. Cash Flow Summary



In conclusion:

	First Year	Second Year	Third Year	Fourth Year
Total Expenses, [USD]	319,960	383,792	424,784	424,784
Total Sales Revenue, [USD]	185,858	650,503	743,432	743,432
Total Margin, [USD]	(134,102)	266,711	318,647	318,647

- Project expected cover its expenses after 20 months, which is 1.66 year.
- Project can provide after reaching a full one shift production steady margin of 26,861.78 USA/Month.

Note: All the above mention calculation based on the average dollar unit rate 15.7 Egyptian pound.

Appendix-6- Reference

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